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Contents for September

Biographical Sketch of Maynard M. Boring, President, ASEE, 1955–56 1
Editorial—A Year of Decision ..... *M. M. Boring* 4
Do You Know 6
Presidential Address: The Elements Glow as They Complete the Whole ..... *N. W. Dougherty* 8
Highlights of the 63rd Annual Meeting of ASEE ..... *J. I. Mattill* 14
Report on Evaluation of Engineering Education 25
Report of the Committee on Ethics 61
University Responsibility in Contacting High Schools ..... *J. F. Downie Smith* 64
YETitudes ..... *P. L. Balise* 73
Survey of Nuclear Engineering Research ..... *H. S. Isbin* 76
Survey on Recognition and Incentives for Good Teaching ..... *H. W. Case* 81
What Industry Expects of the Young Graduate Engineer ..... *John Gammell* 86
Teaching Tips ..... *F. H. Pumphrey* 93
Lamme Award—1955—Vannevar Bush 94
George Westinghouse Award—Robert Roy White—1955 97
Candid Comments ..... *J. E. Dean* 99
T-Square Page
Descriptive Geometry Helps Surveying Instructor ..... *R. P. Vreeland* 100

Section Meetings—106 New Members—104
College Notes—75, 80, 93 In the News—24

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Biographical Sketch of Maynard M. Boring

President of ASEE

The dean of the nation's industrial talent scouts, the new president of ASEE, is well known on the campuses of this country's colleges, particularly those with engineering students.

In more than 30 years of recruiting for the General Electric Company, he has interviewed more than 100,000 prospective candidates for the company's technical training programs.

He is also recognized as one of the nation's leading authorities on manpower and spends considerable time serving on various councils, boards and committees dealing with the problem.

He was born January 26, 1893 in Denver, Colo., eighth in a family of nine children, four of whom were boys and five girls.

His early education was obtained in the public schools of Denver after which he worked his way through the University of Colorado, from which he was graduated in 1916 with a bachelor of science degree in electrical engineering.

On September 1 of that year he was recruited for the General Electric Company's test program at Schenectady, N. Y., the same program to which he later recruited thousands. Two years after joining G.E., in 1918, he was appointed head of motor test. Another year saw him as assistant general foreman of the testing department.

From the factory he was transferred to recruiting and from 1922 to 1940 was in charge of recruiting engineering graduates. In his search for top talent for his company, he has traveled the length and breadth of the land, visiting engineering college campuses for prospective G-E employees.

In 1940, the company increased his responsibilities and made him assistant to the vice president of engineering and put him in charge of not only the recruiting but also the training and education of the technical graduates taken into the company's technical programs.

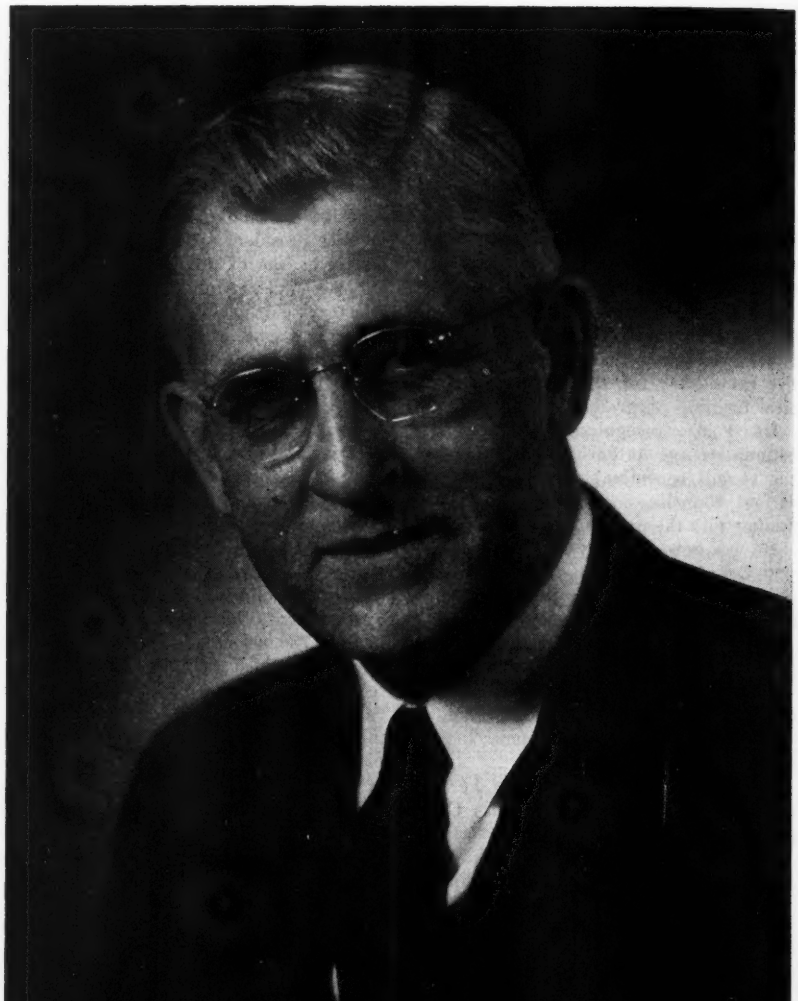
In 1946, he was appointed manager of engineering personnel, and, in 1954, was named consultant on engineering manpower.

It is interesting to note that many of the graduates whom he has recruited have progressed to positions of importance in his company. One of them is vice president of manufacturing and another, the vice president of engineering, now heads the division of which Boring is a member.

His travels have taken him approximately 750,000 miles in search of college seniors qualified to enter his company's technical programs. In addition, he has traveled almost countless miles in serving as an advisor on manpower problems, particularly those relating to the shortage of technically trained manpower.

He has estimated that he has spent as much as half of the normal working time in serving on manpower and other bodies. His interest in education makes it only natural that his home community should recognize his talents, and, in 1937, he was elected a member of the Scotia, N. Y., Board of Education. From 1939 to 1949 he was president of the board.

Joining ASEE in 1922, he served as a member of its council from 1935 to 1938, has been on its Manpower Committee since 1940 and was chairman from 1940 to 1943. He has served on the committee on financial policy, on the committee on Humanistic-Social Project; and the com-



M. M. BORING

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mittee on Evaluation of Engineering Education.

He represented ASEE on the Engineers Joint Council as chairman of the special survey committee and on the Engineering Manpower Committee of the Engineers Joint Council as chairman in 1955. He served as vice president of ASEE from 1951 to 1953 and recently was elected president for 1955–1956.

He was consultant to the War Production Board on Selective Service from 1942 to 1946; is a member of the New York State Appeal Board of Selective Service; member of the Committee on Specialized Personnel, Office of Defense Mobilization; and was a member of the United States Team in 1954 to the European-United States Education Conference, Zurich, Switzerland.

He studied European education and industrial utilization of engineers by traveling throughout western Europe in the fall of 1954.

The new president is a member of the National Society of Professional Engineers, the National Conference Board for Industry of the National Society of Professional Engineers and served as vice chairman of that board in 1955.

He was initiated Eta Kappa Nu in 1937, and elected an honorary Tau Beta Pi in 1941. He received an honorary degree of doctor of engineering from the South Dakota School of Mines in 1952.

His keen insight into the manpower situation is exemplified by the following excerpts from a speech which he made to college students in April of 1942, only five months after Pearl Harbor:

"The trend in college education indicates that a large percentage of those young people who would normally come into industry in the next few years will be diverted into military channels, and a decreasing number will be available to industry.

"We are going to leave you a world torn by war in which we will expect you to correct the social structure and the economic structure, as well as to rebuild the physical things. All of Europe must be rebuilt, and in your thinking you shall have to come to the realization that you must in some way create the same standard of living in European countries that we ourselves enjoy, so that those jealousies that eventually break out into actual wars will be eliminated. You must take a larger part in the economical and social phases of our civilization than ever before.

"I have found from my experiences in contacting young men that most of them seem to feel that their entry into industry will be a very temporary thing, that there is going to be a complete collapse in the industrial world following the war effort; and yet, history shows that even though there may be a short, deep depression immediately following the war, caused by the readjustment necessary in changing over from the building of war material to peace material, this must be followed by a long period of high productivity.

"The fact that there has been practically no building of homes, of heavy transportation facilities, and of power generating equipment for nearly ten years, indicates that there will be a great shortage of such materials facing us immediately after the war is over.

"I feel that we can assure you that the period of rebuilding following the war effort will be one that will be extremely interesting, that you will have a job to do, and that you will have plenty of responsibility, and that you will have grand fun doing this job."

Gardening has been among his hobbies and the irises which he raises are considered the best in the area. Roses are another of his favorities. Fishing—he has a camp at Schroon Lake—is another hobby which he enjoys when he can find the time.

He has been married 33 years. In addition to his wife, he has a daughter, Mrs. W. Curtis Gray of Scotia, and a granddaughter, who, needless to say, is his pride and joy.

A Year of Decision

Editorial by M. M. BORING, *President of ASEE*

The coming year poses a period of real decision. Finalizing the work of the Committee on Evaluation of Engineering Education, new and far-reaching military legislation, President Eisenhower's committee meetings on the public schools this fall, all indicate a good start on a new outlook in our methodology and our goals.

Many, if not all, of our educational institutions will start a revamping of all engineering curriculums according to the recommendations of the Committee on Evaluation, and difficulties and apprehensions will be encountered. We must ask ourselves several vital questions, such as, Can our average freshmen adjust themselves to the new proposals? Can our present faculties adjust themselves to the proposed changes? What will this do to our laboratories? etc.

There are still some questions concerning the Reserve Bill and the Engineering Manpower Commission has tried to keep close to the legislation. This group has testified before both the House of Representatives and the Senate. Both bodies have passed a bill containing a clause permitting 18½ to 20 year old volunteers and men declared "in short supply" by the Government to complete their active service in six months plus a period in a reserve unit and includes a method of screening out reservists from a ready to a stand-by reserve.

Assuming final passage of this proposal, our student population should be able to make better plans for their future and much of the uncertainty encountered since Korea should disappear. We should have a greatly stabilized student body with a better understanding of the necessity of getting to work.

Probably our greatest problem lies in the area of secondary school preparation. The ASEE must work hard to assist the public schools in revamping their programs. This is primarily a local program so that each engineering college must participate.

There is much evidence that the public and our public school people feel the need for changes. Most states have established citizens committees for the public schools. These committees are hard at work studying the problems of our educational system. The influx of students has already started. The shortage of adequate teachers is being felt now. Each of our colleges should undertake a program of cooperative effort with at least the principal schools that supply engineering freshmen in order to develop further interest in those subjects that are vital for entrance into an engineering or scientific field.

Material published by the American Physics Society last April indicates that the percentage of students studying mathematics and science in the secondary schools has dropped from approximately 25 per cent in 1900 to under 4 per cent in 1954. Surveys made throughout the engineering colleges indicate that the average length of time in an undergraduate curriculum is not four years but four and seven-tenths years—the seven-tenths of a year being necessary to overcome secondary school deficiencies.

Is it not possible for us to work with the various state committees for the public schools to rectify this situation? As an experiment, I have brought these problems to the attention of the New York State Committee of which I am one of the directors. These problems have not

been sufficiently recognized in this state, and the members, who have contact with all of the boards of education and administration of the public schools of the state, are very much stimulated to take constructive action.

Considerable concern has been expressed about this problem by members of Congress, by the Department of Defense, by the colleges and others. It appears that the time is ripe for the ASEE to band together for constructive action. It is hoped that President Eisenhower's committee will consider the curriculum as one of the most vital parts of the study for assistance that must be given to our educational system.

It might be well for the ASEE to consider some changes in organization as we are growing larger yet are operating under pretty much the same umbrella as we did when we were just a small group. Our problems are multiplying daily. We might well consider changes in the structure of both the Council and of the administrative committee.

Many of our Sections have become very large and travel distances, at least in some cases, seem to keep down attendance and participation in sectional meetings. If we recognize that our annual meeting should be a period of reporting and of consolidation of activities carried on during the year, it is clear that active participation in section meetings is paramount.

The problem of adequate supply of teachers has become critical. Ways and means must be found immediately to alleviate the teacher shortage. The ASEE must give close attention to this matter during the year ahead.

Industry is finally beginning to recognize its responsibility for financial support to the schools. Many organizations are anxious but do not know how. It is imperative that the ASEE develop realistic, constructive plans to assist industry in making decisions on how financial aid should be handled. It should be of paramount importance at all of our section meetings this year to bring to the attention of industry proper programs for adequate financial support. We all recognize that many times scholarships and fellowships really just add another burden on our colleges and are not very useful in assisting the basic problems.

Your council, your administrative committee and your president will spend much time and effort on these and the many other problems that are before us. We will need help from the membership and hope to develop plans so that we will have as near to 100 per cent participation as possible. Suggestions from individuals and from groups will be most welcome at any time.

Meeting Notices

ECPD 23rd Annual Meeting—Toronto, Canada, October 13–14, 1955, King Edward Hotel.

ASEE General Council—During meeting of Association of Land Grant Colleges, Michigan State College, November 15–17, 1955.

ASEE Annual Meeting, Iowa State College, Ames, Iowa, June 25–29, 1956.

Nuclear Engineering and Science Congress, Cleveland, Ohio, December 12–16, 1955.

College-Industry Conference, Marquette University, tentatively set for February 1 and 2, 1956.

Do You Know—

► The attendance at the Annual Meeting at Penn State was the largest ever. This was the second meeting held at Penn State and each time they set a record. Particularly noticeable was the increased number of women and children. Each member of the Society owes Ken Holderman, General Chairman of the Local Committee, and all members of his Committee a vote of appreciation. Dean E. A. Walker can be proud of his staff and their wives—they did a wonderful job of planning, and the plans were effective. For more detailed information, see John Mattill's article on *Highlights of the Annual Meeting.*

► All of us also owe appreciation to the many committee, division, and program chairmen who planned the programs and conducted the meetings. To those who appeared on the programs as speakers, panel members, or discussers, we also sincerely say, "*Thank you* for a job well done."

► A successful Annual Meeting involves great effort on the part of a great many people; it is doubtful if anyone knows how many. Only through such cooperative efforts can an Annual Meeting be successful. As a Secretary who came into office in the middle of all the planning, I deeply appreciate the effectiveness of the preliminary work of my predecessor, A. B. Bronwell, and his staff. All of you who were involved with the Annual Meeting in one way or another lived up to the confidence placed in you and when you knew you could not get much guidance from the Secretary's office, you continued with your assignments. For that I am indeed grateful.

► Students refer to some of their class experiences as "rat races," "put through the wringer," etc. After having lived through my first Annual Meeting as Secretary of the Society, I now know what they mean! I found out the Secretary's day begins at six A.M. and ends only in the wee hours of the morning when the inevitable discussions and conversations which follow meetings and conferences can be terminated. I missed conferring with many, and to them I apologize and say, "I hope we can get together next year." Mrs. Collins and myself enjoyed the opportunity to meet so many of you at the reception; we hope to meet you again next year at Iowa State. And if the reactions of my children are typical, you made a mistake by not having brought yours to Penn State.

► In electing Maynard M. Boring of the General Electric Company as President, the Society has gone outside the area of university personnel for the second time in its history. The previous president not associated with a university was R. I. Rees, of the American Telephone and Telegraph Company, in 1929–30. In a year when industry as well as each college of engineering is being asked to "evaluate the Evaluation," President Boring should be a great asset to the Society. The new vice president responsible for General and Regional Activities is Frederick C. Lindvall, Chairman, Division of Engineering, California Institute of Technology. The new vice-president by virtue of being Chairman of the Engineering College Administrative Council is William T. Alexander, Dean of Engineering, Northeastern University. George Farnham, Vice-President, Engineering Books,

The Ronald Press Company, was re-elected Treasurer.

▶ Dean B. R. Teare, Jr. of the Carnegie Institute of Technology and Dean W. L. Everitt of the University of Illinois are the retiring vice presidents. To them and to Dean N. W. Dougherty of the University of Tennessee, retiring president, the Society expresses its thanks for the years of service unselfishly given to ASEE.

▶ The new Editor of the JOURNAL OF ENGINEERING EDUCATION is Edwin C. McClintock, Jr., formerly of the University of Virginia. Professor McClintock's background is in literature and speech, but he knows engineers and engineering by virtue of being in the College of Engineering at the University of Virginia, teaching courses in their rather unique program of Engineering English, editing their technical publications, directing their engineering library, and performing a multitude of other duties. At the present time he is a member of our Engineering School Libraries committee.

▶ Copies of the Final Report on Evaluation of Engineering Education were distributed at the Annual Meeting. Copies can now be purchased from the Secretary's Office, University of Illinois, Urbana, Illinois, at the following rates:

1 to 50 copies	25¢ each
50 to 100 copies	20¢ each
100 or more copies	12¢ each

It is preferred that payment accompany each order.

▶ The *1955 ECRC Directory and Review of Current Research* unfortunately was not available in time to be sold at the Annual Meeting. This book is published every two years and it can be purchased for $2.00 per copy from:

Engineering College Research Council
Renato Contini, Secretary
New York University
University Heights
New York 53, New York

Checks should be made payable to Engineering College Research Council.

► The 1956 Annual Meeting will be held at Iowa State College, Ames, Iowa, June 25–29. Professor Lowell O. Stewart, Head, Department of Civil Engineering, is the General Chairman. He and many of his committee chairmen were at Penn State, carefully studying procedures and making notes regarding improvements which would make their meeting even better. Those of you at the Annual Meeting saw the *"Aim for Ames in '56"* sign above their literature. We should all adopt that as our slogan and use it to give the Annual Meeting a little publicity, particularly at Section Meetings.

► Plans for the Open and Closed Conferences on *Theoretical Engineering* are progressing. This is another project jointly sponsored by The National Science Foundation and ASEE. The Closed Conference will be held at the California Institute of Technology and the Open Conference at the University of Michigan. Dates will be announced later.

► The Fourth Summer School for Chemical Engineering Teachers at Penn State was attended by 150 out-of-town people. The papers presented were stimulating and will be published by the Chemical Engineering Division; the Editor of this Division is A. H. Cooper, Professor of Chemical Engineering, University of Maryland.

► The Open Conference on Thermodynamics, jointly sponsored by the National Science Foundation and ASEE, also was well attended. A brief report of the conference appears elsewhere in this issue.

W. LEIGHTON COLLINS, *Secretary*

The Elements Glow as They Complete the Whole

By N. W. DOUGHERTY

President ASEE, 1954–55

(Presidential Address, Annual ASEE Meeting, University Park, Pa., June, 1955)

A mosaic is more than a combination of the elements; it is an arrangement in selected proportion showing forth the genius of the artist. If he has poorly selected materials, the wrong combination of colors or disproportionate sizes of the materials, he will be handicapped in his creation. However, a good artist will make a reasonable production out of good, but disproportionate, materials. Arrangement and proportion have more to do with the final result than the color and shape of the elements; motif and workmanship determine the excellence of the mosaic.

Education is the composite of many experiences; it is the integration of learning, emotions, judgment, integrity and a motivation for service. Many elements are essential for its greatest fruition. Learning from books is a part of it; living from childhood to manhood is a part of it; experiences of pleasure and pain are a part of it; hope, aspirations and longing are a part of it; motivation, a will to do and a drive for excellence are major parts of it. If the student has not confidence, self-reliance and a willingness to stand alone he will never be educated.

In our discussions we are apt to emphasize the elements rather than the whole. For example, this morning we will hear reports on two activities, the one an evaluation of engineering education and the other a study of a major segment of education. Yesterday we heard about graduate work and its evaluation. The overall objective is the production of an engineer; the details of the production have to do with the elements, their shaping, their individual contribution and their blending as a composite of all the elements.

Proportioning the Elements

We often ask the question: "May the methods of analysis and design be applied to the engineer himself?" Certainly not as an automatic mechanism, but possibly as a self-motivating organism. Distinguishing characteristics of an engineer are that he exercises discretion and judgment. Here is one definition of his work:[1]

> The practice of professional engineering within the meaning and intent of this act includes any professional service, such as consultation, investigation, evaluation, planning, design, or responsible supervision of construction or operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, work or projects, wherein the public welfare or the safeguarding of life, health, or property is concerned or involved, when such professional services require the application of engineering principles and data.

This you may say is a staid, pedestrian, prosaic description of the work of an engineer. It lacks the fire and spark of many of his activities and the vision of his greater works. These depend upon the individual and are not necessarily required of all practitioners. As teachers we are concerned with the regimen for

[1] *Model Law*—Joint Committee.

the best, though too often we have set our pace for the pedestrian.

The biographer of Hermann Schneider, by quoting an ancient Indian poem, undertakes to describe the man and the engineer.[2]

> Fearless, singleness of soul, the will always to strive for wisdom; open hand and governed appetites; and piety, and love of study, humbleness, uprightness, heed to injure nought which lives, truthfulness, slowness to wrath, a mind that lightly letteth go what others prize; and equinimity, and charity which spieth no man's faults; and tenderness toward all that suffer; a contented heart, fluttered by no desires; a bearing mild, modest, and grave, with manhood nobly mixed with patience, fortitude and purity; an unrevengeful spirit, never given to rate itself too high;—such be the signs, O Indian Prince! Of him whose feet are set on that fair path which leads to heavenly birth!

Schneider would probably be the first to say that this picture is optimistically drawn, yet if we combined it with the prosaic legal definition we begin to get a description of what we, as educators, are trying to produce.

Academic Elements

The Committee on Evaluation has said some of the elements are mathematics, science, engineering science, technology, the humanities, social science and professional practice. Some of these are so interesting and intriguing in themselves that we are apt to think that our objective is to learn science, engineering science or the humanities rather than to become an engineer whose knowledge and skill is measured by his balance and integration of these separate subjects and skills. Dr. Pollard, in a paper delivered to the Southeastern Section, called it initiation into a community of likeminded practitioners. To be a member of the community of engineering, the person must have a certain kind of knowledge and experience, he must be sympathetic with the group and he must have a peculiar approach to problems and their solution. He is not a scientist, he is not a mathematician, he is not a sociologist or a writer, but he may use the knowledge and techniques of any or all of these in solving engineering problems.

The elements may be combined into a whole by using a formula developed from previous experience. The mixing and the weighting will depend upon good teaching, and more importantly on real assimilation by the student himself. Normally we do not suggest there be a separate program for each individual, but that is what actually happens. I may emphasize one element and my neighbor another, but *the learning is by the student* and his sorting and digesting mechanism determines what he learns and assimilates. Fortunately, education is not like a factory where the superintendent pours in the raw material and a uniform product comes from the line; it is a process where the raw materials are very individual and the final product, if there has been any education, is more individual. Each student does his own blending, coloring and shading of the subject matter he learns.

A few years ago I suggested that educational maturity is the goal. More than ever I am convinced that this is the major objective. We admit youngsters from high school and we graduate young beginning engineers. They must grow from a fledgling to a young eagle; they must put away childish things and take their place among the men. The football coach arranges a hard scrimmage to "separate the men from the boys." It may be a sort of ordeal for some, but it is a separation which must come either in school or in later life. The teacher's job is to help them develop intellectually as rapidly as they can mature. We must arrange our instruction in desirable subject matter areas in such a way that the growing student may consume and digest large quantities. We must remember that an overdose may be as harmful as hunger and scarcity; digestion is the objective and

[2] *Ambassador to Industry*—Clyde W. Park.

not forced feeding or forced dieting because of the leanness of the diet. Rapid and healthy growth is essential, not hothouse plants of figures and facts or encyclopedias or prodigies of rote learning, but oaks of the forest of understanding, originality, self-confidence and intellectual maturity. Students should feel about education, as did Mrs. Miniver about the new hat: "It does something to me."

In a Westinghouse leaflet are these two short paragraphs: [3]

> Something special happens when a new turbine-generator goes on the line. It is not quite like anything you have experienced . . . a combination of quiet rejoicing, assurance that more customers can be served better.
>
> It seems to us that the answer is . . . well, it's *A Way of Life.* Life given to metal and machinery by the brains and brawn of many men, dollars converted into new productive energy, electricity with a magic and miracles at its finger tips.

If we may think and write of a turbine in such terms, how much more may educators think of a way of living for a student who has grown to manhood in an atmosphere of science and engineering and in the association of good teachers.

The objective of the good teacher is to teach himself rather than teach subject matter. His knowledge has become a part of his thought process, and as he labors with his students he reveals his aspirations, his hopes and his desire for knowledge; the subject matter becomes the vehicle by which he makes the revelation.

Since we measure railroads, automobiles, materials, stocks and bonds in money we are tempted to try to measure education in the same coin. Many of us have heard speakers quote figures on compensations for the uneducated, high school graduates and college graduates and convince themselves and their audience that education pays. Surely education is more than dollars and cents. It pays in the coin of the land, but it pays in more than money: "Life consists not in getting and holding, but in being and becoming." Education is more than money and goods; it is living and thinking and understanding and being what you dreamed that you could be.

Education must bend its efforts to get excellence. The average is too low; it must be elevated, and excellence must not be allowed to drift toward good enough.

Formal education, even through advanced degrees, may not be enough. We probably know some Ph.D.'s who have never been outstanding successes as teachers or practitioners, and we know others who have never been to college and who have made names for themselves in engineering. I will make my point by naming a few: Edison, Eads, Westinghouse, Dillworth, and you may add to the list, or I could with equal truth name successes who have had formal college training, as Steinmetz, Roebling, Kettering, Schneider, and again you may name others. These lists probably prove nothing unless we try to identify the common characteristics which led all of them to success. Let me quote from Grantland Rice who may have captured the attitude and the motivation for success: [4]

> To reach the top in any sport—or in life—you need confidence and belief in yourself. Can you imagine Babe Ruth ever considering the possibility of failure? Many years ago, Babe told me, "Once my swing starts I cannot change it or pull up. It's all or nothing at all."
>
> The qualities of self-confidence and belief in oneself seem to be relatively rare today. They are sometimes even openly ridiculed as naive or worse.

I have spent many years observing athletes and their performance as I have in learning about engineers. They have much more in common than we ordinarily suspect. The same qualities make a champion in athletics as make an engineer.

[3] *Partners in a Way of Life.*

[4] *The Tumult and the Shouting*—Grantland Rice.

There is a spirit in sports which we should try to capture in all walks of life. Listen to the Psalmist: ". . . and rejoiceth as a strong man to run a race," who hints at the great pleasure in running a race, in meeting equal competition, yes, "for the give and take of competition—not for the puny bauble that goes to the victor, but for the thrill of the actual game."

Personal Characteristics

Success is due to a combination of many qualities, of which technical education is one. Benjamin Lamme hung this legend in his office in order that all who entered might read: "Promotion stops due to personal qualities long before it stops due to technical ability." When we come to teaching personal qualities we are not nearly so sure of ourselves as when we are teaching information, laws, methods and techniques. We drift into thinking that teaching is covering subject matter rather than developing an attitude, a method and an approach. Success in subject matter is easy to measure, but success in acquiring attitude, engineering approach or engineering method is more elusive and more difficult to measure. Determination, motivation will-to-do set the stage for all degrees of success.

You remember the Mann Report.[5] Some of you will remember the questionnaire to engineers which said: "Please prefix numbers to the groups of qualities listed below to show the order in importance that you give them in judging the reasons for engineering success or in sizing up a young man for employment or promotion:

——Character, integrity, responsibility, resourcefulness, initiative.
——Judgment, common sense, scientific attitude, perspective.
——Efficiency, thoroughness, accuracy, industry.
——Understanding of men, executive ability.
——Knowledge of the fundamentals of engineering science.
——Technique of practice and of business."

These were rated in the above order and when given statistical preference the first four had a weight of seventy-five to twenty-five for knowledge and technique. Personal qualities outweighed the technical ability. No doubt this is true in many other activities of life, such as law, medicine, the ministry and all the professions.

We like to believe that the college instruction determines the field of success, and most of the time it does, but there are times when the success is only remotely related to the college courses. We are all familiar with the transfer of our graduates from one branch of engineering to another, as for example, civil to electrical, mechanical to chemical, and all kinds of engineers to air-conditoning. This is not what I mean; this is to be expected since all engineers have much the same general training. Here and there we have an engineering graduate ending up in the ministry, the law and particularly in business. Again, we believe that the engineering education is, at least partially, contributory to success.

Our surprise comes when we view the works of those who have had no formal schooling and their success equals, if it does not exceed, the hundreds of contemporary college graduates. I am thinking of Dillworth and the diesel locomotive, the Wright brothers and the airplane, Edison and his hundreds of inventions, Eads and the Mississippi River Bridge, Westinghouse and the airbrake, and a long catalogue of others who justly deserve fame and fortune. These were able to achieve eminent success along-side others who had far better formal training. The answer, we say, was in the man; he had native genius which was sufficient without the help or hindrance of a teacher. What he needed to know he learned; when such knowledge was not available he developed it.

[5] Carnegie Foundation Bulletin No. 11.

Herbert Spencer sensed the answer about one hundred years ago when he wrote:[6] "Only when genius is married to science can the highest results be produced." He also said that the greatest intellectual deficiency was that of judgment.

How may we as teachers aid our students in developing their genius for engineering works? Emerson has given us a formula:[7]

> Colleges . . . have their indispensable office —to teach the elements. But they can only serve us when they aim not to drill, but to create; when they gather from afar every ray of various genius to their hospitable walls, and by concentrated fires set the hearts of their youth on flame.

The Dillworth biographer may also give us a hint:[8]

> He learned something from books but even more from the demands of the job and from his associates. . . .
>
> He'd recognize a basic idea wherever he saw it, and he'd remember what happened to it the first time. Whenever he was confronted by involved ideas, his first attack was to reduce them to simple terms. He believed in higher mathematics, but only as a tool to prove or disprove ideas that are basically simple.

This latter statement reminds us of Dr. Doherty's description[9] of the mental workings of Steinmetz. He would reduce a problem to basic elements which could be handled by the use of previous knowledge or experience. Often this approach is the key to great success, and it may be followed by a worker of understanding whether he be a Ph.D. or a boy who went to school one day in his life.

Much of the discussion regarding four, five and six year programs, is born of the idea that engineers must learn in college what they need to know in practice. Patently this is impossible, but the discussion goes on apace under many guises. The study and development must continue through a professional career. It is important that the student get, in one or six years of college, an ability to read and understand, to search and to find and, above all, to get a love of learning. Intellectual dolts do not go far in any field, intellectual sluggards may make some progress, but the lover of learning will learn what he needs to know whenever he needs it. In college the student gets a vocabulary, and some introduction to many fields; he, under good teaching, gets the spirit, the attitude and the approach to scholarship in these fields, and if he works at it for many years he may become educated. As engineering teachers we must see to it that all our students get the professional concept whether they stay in school a year or a decade.

A Further Look at the Whole

The engineer is more than a technician; he exercises discretion and judgment. To do engineering practice he must choose between alternatives; he must follow a service motive, and work in a relation of confidence. These responsibilities are superior to technical knowledge or great mechanical skill; they are the heart of professional practice. In addition the engineer must be a citizen in his community, state and nation; he is an ingenious man which determines one of his major contributions to industry, and coequal, but often neglected, he must assume his place as a statesman in an industrial civilization.

Other elements must leaven the whole mass. He is an individualist which means that he must love and promote liberty. Individuals cannot thrive in an atmosphere of collectivism and herd activities. Bulwer Lytton has written: "Personal liberty is the paramount essential to human dignity and human happiness." This I believe.

Somehow the education of the engineer

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[6] *Education*—Herbert Spencer.

[7] *The American Scholar*—Ralph W. Emerson.

[8] *The Dillworth Story*—Franklin Reck.

[9] *The Development of Professional Education*—Dr. Robert Doherty.

must introduce him to the art of living along with his ability to make a living.

> The average American is a shrewd judge of quality in mechanical products, from motor cars to radios, but his ability to evaluate quality in men and ideas is not equally developed. He is satisfied with no less than the best in airplanes and plumbing but accepts the second-rate in politics and culture. This discrepancy is often excused by the assumption that rising material standards will inevitably raise intellectual and spiritual ones. . . .
>
> Spiritual force and imaginative drive are the only forms of energy that our engineers cannot harness or measure; it is not surprising that they look at them askance.[10]

This suggests that American lack of interest in art allows the modern artist to be hodge-podge in his work. Dashes of color may represent the fuzzy thinking of our day, but they do not represent the needed productions in art. We may write a symphony which will simulate the sounds in a factory, but this will not necessarily be a production of art.

Machines and processes are to make goods. They must not be allowed to use up all the phases of American living. Ideals, emotions, and the spirit must be developed in our youth. That a machine works should suggest that time is available for thinking and dreaming, rather than to grovel and take pride in our possessions.

Have I painted the lily to be seen and admired rather than the engine which works under the hood? The engineer must partake of the virtues of both, and in such proportion as he has skill, efficiency and power he must do the work of his calling, and as he has vision, philosophy of living and dreams for the future he must contribute to making people happy as well as comfortable.

[10] *The Age of Conformity*—Alan Valentine.

The Whole is Greater Than the Sum of the Parts

Kipling's description of the woman as a rag, a bone and a hank of hair falls far short of man's knowledge of the female of the species. The materials are far short of the mosaic. An airplane is a system beautiful, graceful, efficient; it is a monument to its many designers. No one would describe an airplane by naming its parts.

Engineering education is more than the assembly of many courses, lectures and laboratory exercises; it is a preparation for practicing engineering as a profession. Each and every course should be taught with this as its objective. Mathematics, science, engineering science, technology, and the humanities are the pieces and as they are digested, assimilated and become a part of the student they make the mosaic of engineering. Singly they are but subject matter; when assembled into a whole and activated by a professional attitude they become the distinguishing equipment of the engineer. In applying engineering principles and data to design, consultation, investigation, evaluation, planning and responsible supervision, he will partake of the characteristics of Schneider by being fearless, wise, humble, modest and contented of heart that his work may show forth the excellence of his calling.

Special Notice

Members, please return change of address cards immediately to the American Society for Engineering Education. The deadline for the change of address cards is October 1.

Highlights of the 63rd Annual Meeting of ASEE

By JOHN I. MATTILL [1]

Director of Publications and Assistant Director of News Service, Massachusetts Institute of Technology

The yearly stocktaking of engineering education which constitutes the Society's annual convention was accomplished last summer in the peaceful setting of the Pennsylvania hills. But national and international affairs penetrated even these rural surroundings to cast a note of urgency over the entire proceedings.

Comparing Russian scientific progress with ours, Dr. M. H. Trytten, director of the Office of Scientific Personnel in the National Research Council, declared that while "we have not yet come alive to the problem of developing and properly utilizing technically trained manpower, our greatest competitor has.

"We must look promptly to the soundness and well-being of our entire educational system; our concern must be for the millions who will lose their lives or their freedom if we, who should know better, allow our technological superiority to be frittered away."

In the same tone, Dr. Vannevar Bush, receiving the 1955 Lamme Medal at the annual banquet, called engineering education an endeavor "exceedingly important to the strength and welfare of our country."

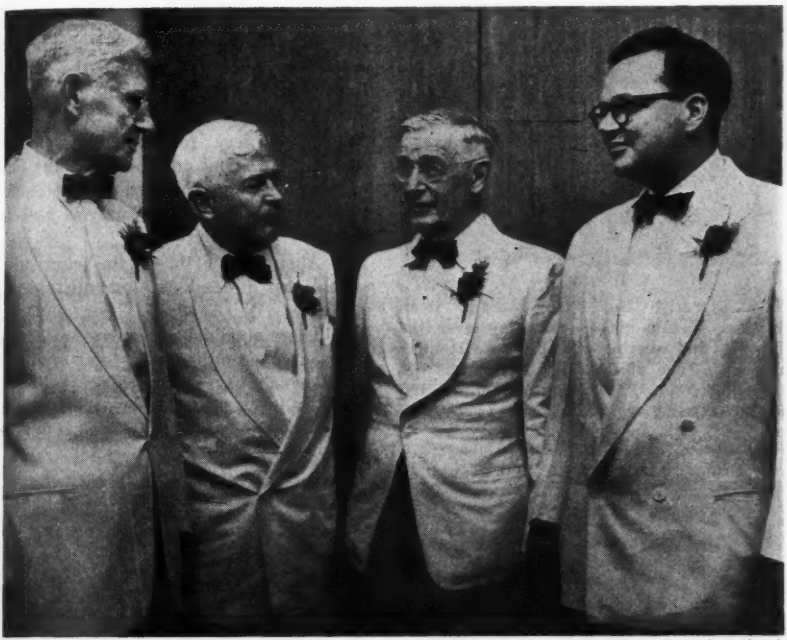
[1] Much of this report is drawn from information prepared for the press during the 1955 Annual Meeting. The author acknowledges the important contributions of Mr. John Whelden, director of public relations at Rensselaer Polytechnic Institute, and of Professor Christian K. Arnold of the Ordnance Research Laboratory at the Pennsylvania State University in preparing press material and hence this summary.

Efforts to meet this challenge—studies of how to make engineering education more effective—were the subject in every hall at the Pennsylvania State University used by the Society during the five-day annual meeting. Few ASEE conventions have been so clearly devoted to only one vital theme.

In his presidential address, the keynote of the meeting, Dean Nathan W. Dougherty called on teachers everywhere to bend their efforts to achieve excellence. "The average is too low," he said. "It must be elevated, and excellence must not be allowed to drift toward good enough." Specifically, said Dean Dougherty, "engineering education must be more than an assembly of many courses, lectures, and laboratory exercises." Educational objectives, he said, should be these: an ability to read and understand, to search and to find, and—above all—to have a love of learning. "Intellectual dolts do not go far in any field, intellectual sluggards may make some progress, but the lover of learning will learn what he needs to know whenever he needs it. Students should feel about education as did Mrs. Miniver about the new hat: 'It does something to me.'"

Final Evaluation Report

The final report on the Evaluation of Engineering Education, another feature of the general session on Tuesday, June 21, contained no revolutionary departures from the previous (1954) interim report of that committee. Basically, the recom-



(Penn State Extension Photo)

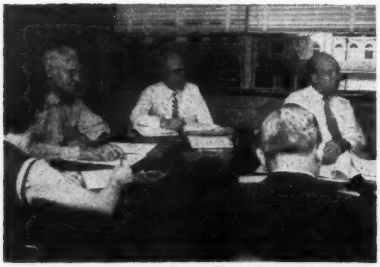
The principals at the 1955 annual banquet pose before entering the ballroom at Penn State; they are, in the usual order, Dean N. W. Dougherty, retiring president who was toastmaster of the evening; Charles E. Wilson, Secretary of Defense, principal speaker; Dr. Vannevar Bush, 1955 Lamme Medalist; and Dr. Robert R. White, Westinghouse Award winner.

mendations were for better understanding of the basic sciences, the engineering sciences, and the humanities and social studies, with less emphasis to be given to rote learning of practical engineering. "Specific details of engineering practice," said the report read by Dean Linton E. Grinter, chairman of the committee, "change too fast to be of value for classroom study except as they may serve the high purpose of illuminating fundamental, unchanging principles. If this criterion is applied rather forcefully by engineering faculties," the report continued, "it is felt that opportunity will be found within the usual time limits to increase basic studies in science and humanities."

As more is learned of the basic sciences, we in engineering have vast new areas for exploitation and new foundations upon which to build, said the committee. "The great changes in physics and chemistry over the past 30 years and the equally great advances in engineering practice do not seem to have produced an equivalent in a reorganization of engineering curricula."

To meet these challenges, the report of the engineering education evaluation committee recommended:

1. Staff members endowed with energy and enthusiasm combined with high technical ability that is applied in a creative manner must be encouraged in every possible way.



(Penn State Extension Photo)

The Executive Board in session: Dean Nathan W. Dougherty presiding over the Board's first meeting at Penn State Monday morning, June 20. At his left is the Society's secretary, W. Leighton Collins, and at the extreme right Dean W. L. Everitt, vice president.

2. In general, the basic sciences—mathematics, physics (including nuclear and solid-state physics), and chemistry—should total about one-fourth of the undergraduate program.

3. To achieve breadth, quality, and penetration, about one-fourth of the total undergraduate program should be allotted to studying engineering analysis and design.

4. About one-fifth of the curriculum should be devoted to humanistic-social studies.

5. There should be electives amounting to about one-tenth of the total engineering program.

6. Graduate education, particularly relevant in engineering fields most closely

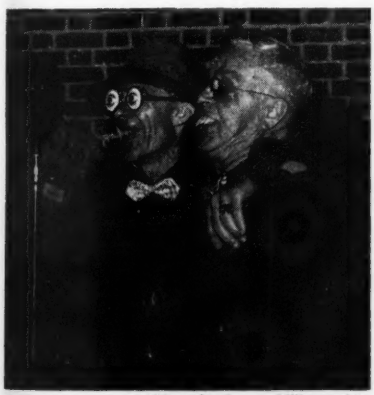
(Penn State Extension Photo)

These five foreign visitors were guests of the Society at the 63rd annual meeting: Professor Leon Christens of the Military College of Belgium, Brussels; LeRoy F. Grant, president of the Engineers' Council for Professional Development and a long-time leader of the Engineering Institute of Canada; John R. Whittaker, principal of the Technical College of Dundee, Scotland; M. Ove Guldberg, secretary of the Danish Engineering Society, Copenhagen; and F. M. Roeterink, adviser on educational affairs at Philips Industries, Eindhoven, Holland.

dependent upon scientific advance, should be devoted to the deepening of insight and understanding and to the development of the stronger intellectual and scientific foundations which are essential to real mastery of the field.

Special Studies of Humanistic and Graduate Work

This final report on the Society's major undertaking of the past three years was accompanied by preliminary summaries from two other self-criticism study projects. Dr. Edwin S. Burdell, chairman of the Humanistic-Social Research Project, said in a preliminary report that his committee will reaffirm earlier recommendations for a "designed sequence of courses extending through the four undergraduate years," representing at least one-fifth of the undergraduate's total time. The matter of integrating these courses is a special problem; indeed, he said, the committee believes that "in the search for unifying concepts, engineering educators are struggling with the most difficult intellectual problem of our time."



(Photo by Lester Millman, '56, from the *Penn State Engineer*)

These two happy Pennsylvania Dutchmen are members of Schwab's Wagon Works Band, which entertained at "en Zammelaaf fer Mansleit, Weibsleit, un Kinner"* on Monday night.

* For those whose Pennsylvania Dutch is not up to this phrase, a literal translation: a get-together for men-people, women-people, and children.

(Photo by Lester Millman, '56, from the *Penn State Engineer*)

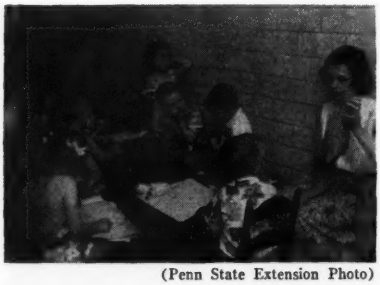
A shady corner on the terrace of the Hetzel Union was a welcome place to relax between sessions.

Dr. Ernst Weber, chairman of an *ad hoc* committee to plan a review of graduate education in engineering, said these five problems justify an intensive study, for which plans are underway:

1. The competition of industrial employers is taking many of the best candidates away from graduate school entrance.
2. Financial support available to graduate students, while apparently inadequate, may be diverting them from the most valuable educational activities.
3. The growth of industrial plans for part-time graduate study suggests the need for new safeguards of academic standards.
4. The spread of graduate work in engineering raises the question of institutions' competency to undertake this exacting educational program.
5. What special types of graduate training may be most appropriate for the more specialized demands of industry?

Broad Self-criticism

Together, these projects of self-criticism constitute a ferment in engineering edu-



(Penn State Extension Photo)

Young visitors spent busy mornings in the University Nursery School—here under the able guidance of Mrs. E. W. Lehmann, whose husband is professor of engineering research in the Ordnance Research Laboratory at Penn State.

cation which cannot be minimized. The session devoted to these reports was the heart of the 1955 meeting. The interest of national groups which have helped make possible these studies—including the Engineering Foundation, Engineers Council for Professional Development, the National Science Foundation, the General Electric Company, and others—speaks for itself. These are intensive studies, with many local committees, participating groups from related professional societies, and corps of field workers. Their impact may not be revolutionary, but it will be clear and long-lasting.

What, for instance, does industry say of these recommendations on engineering education?

"Every sentence of the evaluation report," said F. W. MacDonald of the Guided Missile Division, Firestone Tire and Rubber Company, "has potential energy capable of starting profound discussion. One must be content to say in different words that which has been said so well." John L. McLucas of Haller, Raymond and Brown, Inc., a small electronics research and development company, affirmed that from his point of view the proper equipment for an engineering graduate is a sound background in the basic sciences, an ability to communicate his ideas to others, and an inquisitive nature which will cause him to remain a student throughout his professional career. Speaking for the aviation industry, Vernon Outman of the McDonnell Aircraft Corporation emphasized that an engineering graduate should have "a basic descriptive understanding of a large number of subjects associated with the one in which he specializes."

John Gammell, director of graduate training at Allis-Chalmers Manufacturing Company, reported a survey of engineers' and industrialists' opinions. "Collectively, they indicate a need for adaptable people with broad educations. They emphasize, too, that college is but a prologue to a useful career. A good education is one that stimulates a man to continue growing in whatever direction is necessary."

The research director who looks for new talent for his laboratories, said Chalmer G. Kirkbride, president of the Houdry Process Corporation, wants a graduate who can join a team with other highly trained engineers and scientists. "Too often, the graduate's training in school has neglected the ability to work in a team. Often, too, his training has been too much in the direction of robot in-

(Penn State Extension Photo)

The Society's new president is buttonholed in the union lobby by Dean J. F. Downie Smith of Iowa State College (left) and Professor E. E. Ambrosius of Penn State, who had charge of ASEE conference facilities for the local committee.

tellectuality—too much standardization, too much devotion to the assimilation of factual knowledge at the expense of learning how to think imaginatively." John K. Wolfe, manager of advanced degree recruiting at General Electric Company, reported a survey of the reaction to the interim evaluation report among G. E. engineers and public utility executives. Some of the responses, he said, suggested greater emphasis on the development of students' latent creative abilities—especially in the case of outstanding students who may be neglected because they seem to need help less than others. And some pointed out that with the introduction of the curricular changes proposed, the motivation of engineering students may become a problem: students will receive less actual engineering education early in their college years and may lose interest because little in their courses seems relevant to their final goals.

The study of the humanistic-social stem was anticipated by Dr. Jess H. Davis, president of the Stevens Institute of Technology, who asked for a sharpening of the objectives of such study in the engineering curriculum. These courses should be arranged, he said, so that we can more clearly compare their accomplishments with the objectives we set for them. Indeed, he suggested, we may "set aside the liberal arts tradition and attempt to create one of our own—a techno-humanistic tradition that recognizes and welcomes the influence of science and technology on our times and that attempts to learn from

(Penn State Extension Photo)

Registering the president: Dean Earl B. Stavely, head of Penn State's registration committee, hands his credentials to Dean Nathan W. Dougherty at the opening of registration for the 63rd annual meeting. Assisting is Mrs. Nancy Boodly, Penn State engineering drawing instructor, while Dean Eric A. Walker, whose only responsibility was the weather, watches confidently.

(Penn State Extension Photo)

Teen-agers enjoyed the usual pursuits of the beach at Whipple's Dam, near State College. Standing at the right is John Ditmar, State College's city recreation director, who supervised the outing; the girl in the foreground (in the black suit) is Kay, the daughter of Professor W. Leighton Collins, secretary of the Society; and the half-buried victim is the son of Professor Christian K. Arnold of Penn State, acting the role of perfect host.

the best of man's past and contemporary achievements how to make the wisest use of the new forces now at our command."

A Gracious Host

While intensive self-evaluation was the meeting's principal theme, it was not the members' only activity during five days at the Pennsylvania State University. From the moment of registration until the last suitcase was squeezed shut, the local committee under Dean Kenneth L. Holderman made every minute a pleasant one. Penn State proved to be a gracious host with a spectacular new union building as headquarters, commodious dormitories, good food, and a perfect high-altitude climate of bright days and cool nights. The meeting brought to State College a total of 1587 members of the Society and other professional delegates, with 779 members of their families—a grand total of 2366, the largest annual meeting in the Society's history.* The resolutions committee called the convention "one of the most notably successful and enjoyable in our history."

Full days were planned for everyone. Mrs. C. G. Reen and her committee established ladies' headquarters with a daily coffee hour and ran all-day excursions to Penn's Cave and Old Boalsburg, both flavored with Pennsylvania Dutch tradition. The teen-agers among the visitors soon established themselves in the "tub," Penn State's former (temporary) union building, and made a path to Whipple's Dam, a nearby state park with a fine sandy beach. The facilities of the University Nursery School kept the youngest

* The last meeting at Penn State (1939) set an attendance record which stood unbroken until the 1954 convention at the University of Illinois.

visitors happy, and separate events were planned for grade-school-age children.

Relations with High Schools

One entire general session was given over to the vital problem of attracting high school students to engineering and science. Dean J. F. Downie Smith of Iowa State College, citing the financial difficulties of most secondary schools and their inability to attract competent teachers in the sciences, called on colleges to work with high schools in helping to solve problems of joint interest. This would include, he said, help on providing the types of preparation most effective for college careers in science (but not to do this by a firmly enforced set of entrance requirements), financial aid to high school science teachers, help in guidance and "careers day" programs, and useful educational programming on radio and television.

Speaking of high school science fairs and science clubs, Dr. Watson Davis, director of Science Service, emphasized the value of actual experience in science. "The young person with talent often discovers himself," said Dr. Davis, "through the excitement and satisfaction of tackling a scientific problem experimentally." Encouraging science clubs and science fairs —"the science youth movement," Dr. Davis called it—is an important channel open to college and university people. Ray C. Smith, coordinator of engineering personnel at the Allison Division, General Motors, reported at another session on widespread industrial activities to encourage students in science and engineering. "But," he said, "this is more than a task for industry alone. It is a job for every mature citizen who is aware of the serious shortage of scientists and engineers which we now face—a shortage which is a real threat to the technological and economic future of our country."

(Penn State Extension Photo)

Dr. E. W. Engstrom, vice president for research and development, Radio Corporation of America, filled the Hetzel Union Ballroom on Tuesday evening, speaking on the qualifications industry seeks in potential research workers.

To encourage high school science may be one of the ASEE's principal purposes in the years immediately ahead. One valuable new tool in this work was demonstrated at Penn State: a 16 mm. sound and color motion picture entitled "Engineering—A Career for Tomorrow," sponsored by Eta Kappa Nu and designed for showing to high school audiences. The film, which seeks to show in teen-agers' terms how an engineer tackles a typical job and what he needs to fulfill his assignment, had a warm reception.*

Other Highlights

These other highlights of the meeting —frivolous and serious—were among those reported by the press room:

Their extensive research activities have qualified two more engineering colleges—University of Dayton and University of Virginia—for membership in the Engineering College Research Council.

Dr. Henry H. Armsby, chief for engineering education in the U. S. Office of Education, saw his birthplace for the last time during the convention. He was born in a little house almost directly across the street from the Hetzel Union at Penn State, and the house is soon to be razed to make room for a growing university. He will get the fireplace decoration, courtesy of Penn State.

At its first session Monday morning, the Society's Executive Board heard Professor W. Leighton Collins, secretary, report the national membership at a new high of 7560. The Society's total financial operations for 1954–55 reached $85,640, also a new record high.

Special ceremonies were held during the convention by five technical institutes, charter members of a new non-profit foundation to "develop technical-institute-type education in the United States through mutual efforts of the independent, non-profit institutions." Karl O. Werwath, president of the Milwaukee School of Engineering and one of the signers of articles incorporating the new foundation, said it will "disseminate information about technical institute education, develop curricula and schools, and otherwise promote the interests of these institutions."

An early arrival in State College was Miss Nell McKenry of Pittsburgh. She was the Society's assistant secretary from 1918 until her retirement in 1948, and she spent the meeting shaking hands of old friends and (successfully) dodging the press room's cameraman.

The 1956 meeting of the Society will be Iowa State College, Ames, June 25–29.

An initial grant of $6000 from Arthur Williston, former director of Wentworth Institute, Boston, and of the School of Design and Technology, Pratt Institute, Brooklyn, was accepted by the General Council to begin a broad study of two-year technical institute education in the United States. Dean Dougherty, in announcing the plans, promised "a comprehensive study of the philosophy, fundamental concepts, services, and potential-

(Photo by Lester Millman, '56, from the *Penn State Engineer*)

Two ASEE visitors study the control panel of Penn State's new reactor, soon to go into operation. The ASEE's tours duplicated one a week earlier by President Eisenhower, who was Penn State's commencement speaker.

* Distribution of the film is being arranged through the Chicago Alumni Chapter of Eta Kappa Nu. Write to T. E. Farley, Room 301, Illinois Bell Telephone Company, 208 West Washington Street, Chicago 6.

(Penn State Extension Photo)

Dr. Maynard M. Boring (left), consultant on manpower at the General Electric Company, receives congratulations from his predessor, Dean N. W. Dougherty, upon his election as president of the Society.

ities of the technical institute form of education."

A new medal to recognize outstanding engineering college research will be awarded beginning in 1956 by the Engineering College Research Council. The annual award will be made on the basis of "achievements in and contributions to original research, research administration, leadership influencing the productive research of others, or the effective application of research results to the advancement of engineering education."

Although most Americans have not yet seen an atomic energy device, this country's peacetime nuclear industry is so well along that it has a pressing need for engineers who can aid in its development. Dean G. A. Hawkins of Purdue University said the industry's ranks are now being filled by engineers originally trained in other fields; the immediate need is for graduates with an aptitude for research, development, and design and a basic knowledge of nuclear physics and other associated fields. Students talented at such things as construction, operations, and sales will not be needed until later. H. A. Wagner of the Detroit Edison Company warned that "the need for nuclear engineers in the electric power industry will exceed the supply for at least the next ten years."

The Engineering College Research Council, reporting its biennial survey of American engineering college research, said that at least 20,000 teachers and their students—probably the largest number in history—are participating in a "strong and dynamic" program of research in engineering education institutions, a program valued at more than $110,000,000 annually. Dr. Harold K. Work of New York University said that "because of the research sponsored at American universities by government and industry, many engineering graduates today are better equipped than ever before to help themselves and their employers." More than 6500 individual research projects are tabulated in the Research Council's 1955 *Review of Current Research,* just off the presses.

Dean C. J. Freund of the University of Detroit reported for the committee on ethics, of which he is chairman, that nearly half of the country's engineering schools give their students lectures or conferences on general or engineering ethics. In another fifth of the schools, some less formal activity is used deliberately to bring the question of ethics to students' attention. The importance of this subject was stressed by Kenneth A. Meade, director of educational relations at General Motors Corporation, who declared, "The role of his profession places upon every engineer the serious responsibility of doing his work and directing his life according to the highest professional and moral standards that men of integrity can establish and achieve."

From the Young Engineering Teachers Committee came a proposal for a summer workshop, designed especially for teachers of less than five years' experience, to provide an organized program of prepara-

tion for teaching careers. Winners of YET awards for essays on engineering education were Harold A. Foeke of Notre Dame University (first place), Donald R. Lamb of the University of Wyoming (second place), and Edward J. Rising of Kansas State College (third place).

The Engineering College Research and Administrative Councils, at their combined banquet, heard Dr. E. W. Engstrom, executive vice president for research and engineering at Radio Corporation of America, list 10 qualities which industry seeks in its research workers: creativeness comes first, since the creation of new understandings, new principles, new products, or new services is indeed a definition of research; training in fundamental science is second only to creativeness; character—complete reliability in prosecuting a research program—is richly rewarded, yet "it is rarer than one might think"; vision is the fourth requirement: "creativeness coupled with vision to treat the creation objectively makes for greatness in research;" initiative and enthusiasm are the next in line of requirements, followed by scientific inquisitiveness and practical outlook.

Secretary of Defense Charles E. Wilson, principal speaker at the ASEE's annual banquet, pointed out that 50 per cent of the nation's scientists and engineers are now directly or indirectly working on national defense projects. "Our hope of peace," he said, "rests on our maintaining national strength during the years ahead while men of good will study ways to achieve international understanding."

In the News

"The colleges must join hands with industry in creating a good atmosphere for professionals to grow," urged N. W. Dougherty, Dean of Engineering at the University of Tennessee and Junior Past President of the American Society for Engineering Education. Speaking on the role of engineering education in engineer-industry cooperation at the 21st Annual Meeting of the **National Society of Professional Engineers** in Philadelphia, Dean Dougherty traced the development of engineering education since its introduction in the United States.

It is also the responsibility of colleges to produce a beginning engineer who will grow into ripe maturity and take his place in research, design, operations and management, said Dean Dougherty. He added that it was time that colleges taught their students the difference between a skilled workman and a professional.

Thanks to the recommendation of the ASEE Committee on Atomic Energy Education to the **Atomic Energy Commission**, Dr. Samuel Glasstone's "Principles of Nuclear Reactor Engineering" was published in August. The AEC approved the ASEE recommendation and hired Dr. Glasstone to prepare the sourcebook. Taking into account Dr. Glasstone's "Sourcebook on Atomic Energy" as a model, the Committee had recommended that he prepare the proposed text.

After the manuscript had been completed and reviewed by the subcommittee of the ASEE Committee, which was appointed specifically for that purpose, the Committee accepted the subcommittee's recommendation that Dr. Glasstone's text be accepted. The ASEE Committee feels that this book will be very useful in assisting engineering educators to incorporate nuclear materials into the engineering curriculum.

Summary of the Report on Evaluation of Engineering Education*

Engineering Education must contribute to the development of men who can face new and difficult engineering situations with imagination and competence. Meeting such situations invariably involves both professional and social responsibilities. The Committee considers that scientifically oriented engineering curricula are essential to achieve these ends and recommends the following means of implementation:

1. A strengthening of work in the basic sciences, including mathematics, chemistry, and physics.

2. The identification and inclusion of six engineering sciences, taught with full use of the basic sciences, as a common core of engineering curricula, although not necessarily composed of common courses.

3. An integrated study of engineering analysis, design, and engineering systems for professional background, planned and carried out to stimulate creative and imaginative thinking, and making full use of the basic and engineering sciences.

4. The inclusion of elective subjects to develop the special talents of individual students, to serve the varied needs of society, and to provide flexibility of opportunity for gifted students.

5. A continuing, concentrated effort to strengthen and integrate work in the humanistic and social sciences into engineering programs.

6. An insistence upon the development of a high level of performance in the oral, written, and graphical communication of ideas.

7. The encouragement of experiments in all areas of engineering education.

8. The strengthening of graduate programs necessary to supply the needs of the profession, conducted in those institutions that can:

   a. provide a specially qualified faculty,
   b. attract students of superior ability, and
   c. furnish adequate financial and administrative support.

9. Positive steps to insure the maintenance of faculties with the intellectual capacity as well as the professional and scholarly attainments necessary to implement the preceding recommendations. These steps include:

   a. well-established recruitment, development, and evaluation procedures,
   b. favorable intellectual atmosphere, reasonable teaching loads, and adequate physical facilities, and
   c. salary scales based on the recognition that the required superior faculty can be secured only by competitive remuneration, since professional practice in industry and government is inherently attractive to the best minds in engineering.

10. The consideration of these recommendations at this time before the problems of educating greatly increased numbers of engineers become critical.

* This project was financed in part by contributions from the constituent societies of ECPD, the Engineering Foundation, the General Electric Company, and the National Science Foundation.

Report of the Committee on Evaluation of Engineering Education

Objectives of Engineering Education and Their Implementation

Foreword

The Committee on Evaluation of Engineering Education of the American Society for Engineering Education (ASEE) was appointed in May, 1952, by President S. C. Hollister. This action followed a recommendation of the 1951 ECPD * Committee on Adequacy and Standards of Engineering Education and also followed discussions within the Engineering College Administrative Council of ASEE, the Education Committee of ECPD, and the General Council of ASEE. The charge to the Committee was to recommend the pattern or patterns that engineering education should take in order to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century.

The Committee on Evaluation began its work in June, 1952, at the Dartmouth meeting of ASEE. The Education Committee of ECPD immediately requested the Committee to give consideration to the development of standards that might aid ECPD in bringing engineering accreditation in consonance with future responsibilities of engineers. The Committee on Evaluation was asked particularly to clarify the curriculum content that differentiates engineering education from that in science on the one hand or in subprofessional technology on the other.

* Engineers' Council for Professional Development.

In order to enlist the aid of engineering educators throughout the United States in this important undertaking, the Deans of all engineering colleges having accredited curricula were invited to appoint Institutional Committees to conduct their own studies on evaluation of engineering education. A series of questions expressing the broad problems confronting engineering education was sent to these Institutional Committees to form the basis of exploration. The discussion of these questions by the Institutional Committees and the ASEE Committee culminated in the preparation of a series of institutional reports and in the Preliminary Report on Evaluation of Engineering Education, which was issued in October, 1953.

This Preliminary Report was distributed for critical review to all colleges with accredited engineering curricula. The response of the institutions was extraordinary and resulted in an extended analysis that was nation-wide in scope. Reports embodying the criticisms which developed were received from 122 Institutional Committees. Study of these recommendations by the main Committee aided it in understanding the nation-wide thought of engineering educators. Many of these recommendations and those expressed in the previous evaluation studies outlined in Appendix A, together with those of the Committee itself, formed the basis for an Interim Report on Evaluation of Engineering Education published in June, 1954. Critical review of the Interim Report was sought and obtained. All institutions were asked to review the Report and submit criticisms. Several hundred copies were mailed to as many industrial concerns with requests for criticisms.

Over eight thousand copies of the Interim Report were purchased in the first four months, which indicated both the wide interest of faculties in the Report and the extent of its distribution. It was also placed in the hands of all ASEE members by publication in the September, 1954, *Journal of Engineering Education.*

From the comments received from individuals, Institutional Committees, industrial companies, and societies, the Committee has concluded that the Interim Report has been accepted as pointing the trend for the evolution of engineering education over at least the next decade. Hence, this final Report follows basically the same line of development as the Interim Report. However, the comments received indicated two weaknesses that are believed to have been remedied.

First, the Interim Report failed to give adequate emphasis to the graduate phase of engineering education. This weakness has been corrected by expanding the former section on graduate work. However, since this new section in the final Report deals only broadly with graduate study, it is recommended that those interested in the details of graduate education refer to *A Manual of Graduate Study in Engineering,* published in 1945 as an ASEE Committee Report (*Journal of Engineering Education,* Vol. 35, p. 650) and reissued in 1952 in monograph form.

Secondly, comments which were received, particularly from industry, placed great emphasis upon the inability of engineers to express themselves in clear, concise, effective, and interesting language. Stress was also placed upon the importance to engineers of an acquaintance with the humanities and social sciences. This has led the Committee to reconsider the place of non-technical studies in an engineer's education, with the result that this final Report places greater emphasis on humanistic and social study and effective communication. Since a special investigation of humanistic and social studies in engineering education is being conducted by another ASEE committee, the subject is treated broadly rather than in detail in this Report.

Studies were also made and comments received from committees appointed by other societies at the request of the Committee to consider the teaching of physics and of mathematics to engineers. The American Association of Physics Teachers (AAPT), the American Institute of Physics (AIP), the Mathematical Association of America (MAA), and the ASEE Divisions of Physics and Mathematics all had committees participating in these studies. Although only one of these was a joint committee, the others served this purpose because of the overlapping membership involved and the joint meetings scheduled. The ASEE requested the National Science Foundation to support various conferences in these areas. Its generous response in supplying the needed funds and the enthusiastic cooperation of the committees involved made additional comments available which assisted the Committee in formulating the revisions incorporated in this final Report.

The Committee expresses its appreciation to the Engineering Foundation, the constituent Societies of ECPD, the General Electric Company, the National Science Foundation, and the General Council of ASEE for the financial assistance which made this study possible.

Objectives of Engineering Education

The determination of the pattern which engineering education should take in the future must, of necessity, be based upon the obligations of the engineering profession to society and upon the importance of the development of the student as an individual. The obligations of an engineer as a servant of society involve the continual maintenance and improvement of man's material environment, within economic bounds, and the substitution of labor-saving devices for human effort. Moreover, his activity usually has a direct bearing on the welfare and safety of large segments of society. Like the physician,

the engineer must work within the current limitations of the state of his art and must decide which one of several possibilities provides the best solution to a given problem.

Engineering is far from static, for it is essentially a creative profession. It has played a dominant role in building American industrial superiority, in developing the principle of mass production, and in giving the American people their high standard of living. The continuing growth of our knowledge of basic science has opened vast new areas to engineering endeavor and has enlarged the foundations underlying many of the existing engineering fields. Some fields of engineering have been reasonably alert in assimilating new scientific advances into their teaching programs. It is one purpose of this Report to encourage *all* fields of engineering education to move in this direction.

Any attempt to specify the content of an engineering curriculum must be preceded by the development of a clear understanding of the objectives of such professional education. These objectives are two-fold and are based on the technical and social responsibilities that must be assumed by graduates expecting to enter the engineering profession. The entire professional educational process is more inclusive in scope than an undergraduate engineering curriculum, for it also includes training in high school and post-baccalaureate study in a university or in industry, along with continual self-study and with experience in engineering practice before full professional status can be achieved.

Technical and Social Objectives—The first objective, the technical goal of engineering education, is preparation for the performance of the functions of analysis and creative design, or of the functions of construction, production, or operation where a full knowledge of the analysis and design of the structure, machine, or process is essential. It also involves mastery of the fundamental scientific principles associated with any branch of engineering, including a knowledge of their limitations and of their applications to particular problems, such as the development of materials, machines, or structures as well as the ability to make critical scientific and economic analyses and to organize these into clear, concise, and convincing oral or written reports.

The second objective, the broad social goal of engineering education, includes the development of leadership, the inculcation of a deep sense of professional ethics, and the general education of the individual. These broad objectives include an understanding of the evolution of society and of the impact of technology on it; an acquaintance with and appreciation of the heritage of other cultural fields; and the development of both a personal philosophy which will insure satisfaction in the pursuit of a productive life and a sense of moral and ethical values consistent with the career of a professional engineer.

These technical and social objectives should be met in a manner which will provide the individual with an enlightened background that will give him the means and the inspiration to grow on his own initiative before and after graduation. An undergraduate curriculum must serve a two-fold purpose of preparing some men for immediate employment and others for graduate study. This Committee believes that in any one field a curriculum with a reasonable degree of flexibility, as represented by electives, can meet both of these needs.

Implementation of Objectives

A number of factors influence the effectiveness of engineering education. Of these, the selection and development of a faculty and the relation of the curricular content to the objectives of engineering education have received the greatest emphasis in the nation-wide discussions that have taken place, and they form the central theme of this Report. Admission requirements, high school-college articulation, existence of adequate facilities, pro-

vision for gifted students, and the significance of graduate programs are also considered for their effect on the implementation of any suggested changes in present programs. Nevertheless, thoughtful consideration inevitably leads to the conclusion that the character and quality of the faculty are of controlling importance. Therefore, the selection and development of the faculty is considered first.

The Selection and Development of an Engineering Faculty

Distinguished faculties are far more important to the advancement of engineering education than details of curricula or magnificence of facilities. The university is a community of scholars and as such requires outstanding teachers to attract outstanding students. To improve and develop courses or curricula, to build up facilities—in short, to command respect as an educational institution—all require a faculty of competent teachers and scholars.

A thoroughly competent faculty can be acquired and maintained only if the college administration gives discriminating attention to the important problems of recruitment, selection, training, advancement, and termination of appointment. Logically, however, the selection of competent staff members can be undertaken only after long-range curricular objectives have been formulated.

University and College Environment

The academic and professional development of an engineering faculty can proceed only in a favorable environment. More important than physical surroundings is the intellectual atmosphere; that is, the attitudes and ideas of the people who comprise the university. A common inner urge to know and to understand is basic to this atmosphere and leads to unity of purpose—the mutual selection of common goals and coordination of effort toward their achievement. There must be encouragement of intellectual growth and opportunity for professional development such as is involved in the teaching of graduate courses. Teaching loads must be kept at reasonable levels to allow time for scholarly or creative activities. The development of such a favorable academic atmosphere should be the concern of all faculty members, particularly those in senior administrative posts.

Physical surroundings also contribute to a favorable environment. Facilities may be modest or extensive, as long as they are in harmony with and effectively serve the curricula. Besides adequate classrooms and laboratories, the individual teacher needs appropriate office space, research facilities, technical services, secretarial help, and an effective library. An adequate library, its accessible location, and its required use are essential elements in any educational process.

The atmosphere of a university has a significant influence on student progress. Students need a close bond of mutual interest and friendship with members of the faculty. They need objective guidance and encouragement in their intellectual growth; they need sympathetic understanding of their personal problems; but above all, they need the realization that they are being treated as individuals. An administration and a faculty which are genuinely concerned with these responsibilities are most likely to create a favorable student environment.

Qualifications of Teachers

Any teacher at the university level must have notable intellectual capacity and a sustained interest in a life of study for continuing mastery of his field—obvious qualifications that nevertheless merit explicit statement. To teach well, he must know and understand, clearly and in perspective, his own and supporting fields at a much more penetrating level than that required in his lectures.

The enginering teacher, in addition, must have a full appreciation of the goals to be achieved. He should realize, first of all, that a course can be taught either

as a narrow specialty or as a liberal subject in a professional curriculum; he should strive for the latter. Such a liberal course is one in which the teacher inspires his students toward creative endeavor and intellectual development not only while they are in college but also throughout their careers. It is one into which he brings recognition of the importance of intellectual honesty and professional integrity. To achieve these goals he should possess energy, enthusiasm, and a sincere interest in the development of men. To be fully successful he must exercise judgment and tact, and have the ability to meet the minds of his students. *He should perform creative work whether it be in teaching, writing, research, or professional activities.*

The selection of individuals for faculty appointments requires a careful evaluation of their qualifications. Good teachers have always been personally creative and capable of inspiring their students to creative endeavor. In the past they necessarily emphasized the art or practice of engineering. However, during the lifetime of present faculties the art of engineering has come to depend greatly upon basic and engineering science. It must also be recognized that universities are better equipped to teach the science underlying professional practice, whereas industry is better adapted to provide experience in practical applications. Within a faculty there should exist a balance of experience in both the science and the art of engineering.

Education and Experience

For a relatively young candidate for a faculty position, the strongest evidence usually available to measure a background of integrated fundamental knowledge and probable creative ability in teaching and research is an education which includes the doctor's degree. However, unless an academic environment is provided that will stimulate and retain men with an interest in creative work, mere insistence on degrees will not insure high quality in a faculty. For experienced persons, evidence of the capacity of the individual for creative teaching and research may be gauged by other criteria, and the formal educational background is of less significance.

Young engineering teachers who hold only the bachelor's degree should be employed only in a temporary position that presupposes a continuation of their education. Lack of such progress should be sufficient reason for terminating their appointments.

Appropriate professional experience in industry, government, or private practice is important in a well-balanced faculty. This experience should be considered in the selection and advancement of individuals, but it need not be a requirement for faculty members with a special educational background or with demonstrated creative ability in research or teaching. Every teacher, regardless of his background, should strive to become a recognized expert in his field. There is no substitute for knowledge of subject matter far beyond the limitations of that to be taught. However, it is recognized that mastery of subject matter alone will not guarantee good teaching and that neither industrial experience nor advanced degrees are adequate criteria in themselves. The minimum essentials for good teaching are the mastery of subject matter and the capacity of the teacher to draw students into active participation in the learning process. Strong individuality is often characteristic of distinguished teachers, but the capacity to cooperate with colleagues in carrying out the institutional program as a whole is nevertheless of great importance. The special qualifications of teachers participating in the graduate program are referred to in the graduate section of this Report.

Recruitment of a Faculty

Of paramount importance to any profession is the personnel of that profession. No time can be spent more profitably by administrative officers than that required for recruiting and developing competent

teachers. Recruitment of a faculty embraces the search for persons whose abilities, aptitudes, and personalities are of the desired type; telling them of the opportunities, environment, obligations, and limitations of the profession; ascertaining whether their ideals and ambitions are consonant with those of the profession and the school; and, finally, arranging suitable compensation for and other terms of employment.

New teachers are often recruited from among those students who have just finished study of a part of the wide field of engineering and science. It is recommended that promising undergraduate and graduate students be sought out and their aptitudes as potential teachers be appraised early in their schooling. If a student's interest is aroused in a teaching career, his study may be guided to embrace breadth of view and scholarly attitude. Such a program should help to recruit and develop teachers who will carry the responsibility of improving engineering education to meet the needs of the future. Care should be exercised to avoid excessive inbreeding: *heterogeneity of faculty backgrounds is inherent in the very concept of a university.*

The effective recruitment and retention of a qualified faculty will require, in colleges of engineering, the establishment of a salary scale comparable to the income earned by outstanding practicing professional engineers as indicated by the published surveys of national societies. Accepted practices in establishing adequate faculty salary scales in the professions of medicine and law indicate that competitive situations must be met if professional education is not to stagnate. It should be recognized that, in contrast with the situation in many academic fields, industry is inherently attractive to many of the best engineering minds. Unless the salary differential is minimized, a sufficient number of superior engineers will not be attracted to or retained in the teaching field, to the detriment of the whole profession, of industry, and of the nation.

In faculty recruitment, industrial or other experience is an important measure of professional qualification. However, one needs to look very closely at the nature and character of this experience to determine its relevance to engineering teaching. Of greatest significance is not the number of years of experience, or even the administrative responsibility that the individual may have carried, although these are not unimportant, but rather evidence of the use of intellectual qualities in professional practice, such as creative design or development, including patents, and research contributions involving reports and publications, or other experience of an analytical or creative nature. One might appropriately ask the following questions. Can the potential teacher articulate his engineering work with the underlying basic science and engineering science? Has his work been such that it has kept his background of science alive or, better yet, in continuous development? Many practicing engineers achieve results by the use of a kind of intuitive sense which, no matter how successful in practice, cannot be transformed into organized knowledge that can be taught to engineering students.

Development of a Faculty

Even though the environment and salary scale of an engineering college may be such as to attract and retain an outstanding faculty, the newer members of such a group will usually need guidance in the techniques of teaching. Their study of the ASEE Report on the *Improvement of Teaching* (*Journal of Engineering Education,* Vol. 43, No. 1, Sept., 1952) should greatly enhance the effectiveness of their teaching. The primary purpose of an engineering college is to provide effective instruction in subject matter through the stimulation and motivation of students, and it is essential that those selected to teach be trained properly for this function. Such instruction may be made more effective by proper organization of subject matter, by teaching elementary as

well as advanced courses in a given field, and by teaching subjects in related fields. *The teacher's own use of and insistence on the student's use of clear English, both oral and written, should be considered as an essential part of his teaching of any subject.*

Although experienced teachers will generally perform more effectively than young instructors or graduate assistants, it is possible to achieve excellent results with the latter. Graduate student teachers usually bring into the classroom a youthful vigor, an enthusiasm, and a fresh point of view that are highly commendable. They may also lack professional judgment and maturity to such an extent that they may not give the undergraduate student a sufficiently balanced kind of teaching. However, with careful selection and supervision of assistants and through course organization it is possible to provide competent instruction by teaching assistants. The teaching assistant must accept a responsibility as great as he would have in industry and should be asked to recognize his teaching job as a principal occupation, along with that of graduate study. Furthermore, teaching is a beneficial part of the educational experience even for those who later elect industrial pursuits.

Seminars, discussion groups, formal and informal conferences between experienced and inexperienced teachers can all be used effectively for the development and growth of a faculty. Informality in such arranged programs has merit so long as it does not lead to irregular participation. To maintain interest, such programs must be varied in form from semester to semester.

It is important that faculty members set an example for their students by their membership and active participation in professional and technical societies, by becoming licensed engineers, by study of current literature, and by demonstrating interest in new developments and in research. Such leadership among faculty members is particularly necessary in institutions that are able to provide only limited opportunities for research, for leadership contributes an important element of vitality to teaching. The spirit of leadership that also creates in the student a desire to lead is of the greatest importance. It can be developed by teachers who are men of stature, judgment, wisdom, and tact. The ambition for leadership should involve ascendence in a technical field and a desire to serve society.

In engineering teaching, continual contact with the forefront of engineering and scientific progress is essential. Leadership in scientific and engineering progress has frequently stemmed from university research activities. *The engineering teacher carries a responsibility to contribute to the advancement of knowledge through engineering research. The university must provide the opportunity to realize this objective in terms of time, facilities, and assistance.*

It is only when teachers of professional subjects are recognized as experts that they have an opportunity to do consulting work. Hence, the ability to engage in such consultation is not considered to be a major factor in the recruitment of young teachers. Consulting practice should be considered as a means of developing and further strengthening an engineering faculty. Close association with engineering work or research in industry should stimulate the teacher and improve his teaching. Consulting is also a source of ideas for research. The limit upon the useful extent of this activity has not been determined. However, the belief is widely accepted that an average of one day per week of the individual teacher's time devoted to consulting activity of a high professional character will reflect to the overall advantage of the institution.

Evalution of a Faculty

Evaluation of the potential of prospective faculty members and of the achievement of the existing staff ranks with the development of a progressive atmosphere as a most important function of a university administrator. Systematic and regu-

lar methods of evaluation rather than haphazard ones are essential as a guide for recruitment and for making salary adjustments and promotions. Definite policies on termination of appointment for those who do not live up to their expected performance are also necessary for proper development of a strong faculty.

It would be most desirable if this evaluation could be done on a quantitative basis, but the Committee is not aware of any systems which warrant recommendation for general adoption. The Committee suggests that there be more experimentation by individual institutions in the development of quantitative systems of faculty evaluation. Any evaluation system can serve only as a partial guide, since personal judgments must remain the most important factor. The Committee recommends that such quantitative systems as are developed be reported at meetings of the Society and in the Journal. The success of some industrial evaluation systems indicates that there is hope for progress in this area.

The fact that evaluation of the progress of a faculty member must be based on judgment involving many factors indicates that administrators at each level should inform themselves of the viewpoints of their faculties before reaching these judgments, realizing that there are dangers in judgments made by associates of the individual concerned. In particular, the faculty should be informed as completely as possible concerning the methods used in evaluation.

Evaluation, to be effective, should be objective, and it should include along with other factors all the items mentioned in the section on Qualifications of Teachers, with emphasis upon:

1. The effectiveness of the individual's teaching based upon his knowledge of subject matter, intellectual capacity, judgment, professional and personal stature, and qualities of personal leadership as shown in his ability to inspire students.
2. His productivity in research and other creative areas including new methods of presentation of subject matter.
3. His professional development as evidenced by progress in early years toward advanced degrees, by accomplishments in engineering practice, or by attainments and recognition as a scholar in his field.
4. His significant publications.
5. Evidence of his professional interest as shown by his activity in professional societies and in governmental and community affairs, and by his registration as a professional engineer.
6. The nature and responsibility of his consulting services to other areas of the university and to outside organizations.

It is important that administrators periodically advise members of the staff regarding their standing, particularly those members who should be encouraged at an early date to abandon a teaching career. Mere lack of promotion or of salary advances should not be assumed as a sufficient method of criticism for individuals who are not developing according to the standards expected.

It is equally important to stimulate the good teacher by verbal or written approbation, either for his general progress or for his special accomplishments. *It is essential that those staff members endowed with energy and enthusiasm combined with high technical ability that is applied in a creative manner be compensated in the fullest measure.*

An adequate staff either in a departmental faculty that is responsible for a curriculum or in a major supporting group will have at least one teacher in every five who has attained professional distinction. Such individuals will (1) be conducting high-grade research of an engineering or educational nature, or other creative activity, including publishing work of good quality, (2) be engaged in consulting work at a creative level, (3) be exercising leadership in scientific, educational, and professional societies, or preferably, (4) be serving in a combination of such activities.

Curricular Content as Related to the Objectives of Engineering Education

Instructional Goals

The ultimate goal of engineering education is the development of able and responsible men fully competent to practice on a professional plane, especially those who will eventually lead the profession to new heights of accomplishment through creative practice or research. The student, not the curriculum, is the primary concern, yet the curriculum has an important influence on education. Before considering curricular components, the instructional goals toward which they are directed should be examined.

The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles, on his own initiative, with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology and to continue to grow intellectually in both professional and cultural areas throughout life.

In professional engineering practice the "new situation" often involves social and economic as well as technical elements, and these are not entirely separable. Thus the end result is not merely the numerical solution of a technical problem but is rather a decision based on a value judgment to which the quantitative technical result contributes one important element. In fact, the significant problems involving engineering seldom occur in well-defined form. Hence, the initial stage of thinking is often an intuitive groping to identify specific component problems. Their solution, in turn, requires the application of thoroughly understood fundamental principles and well-ordered analytical thinking in defining the problem, planning its simplification without losing its essential nature, conceiving a method of attack, carrying the study through to a successful conclusion, and checking the results at each stage. This technical solution is then available to guide the engineer when he considers the broader social and economic aspects of the problem. His final decision will be influenced by the extent to which his perspective and judgment transcend purely technical matters.

Engineering educators must never lose sight of the broad issues with which large engineering problems are always associated, although the ability to deal effectively with such broad issues comes only with experience and maturity in the years after college. The importance of keeping such economic and social ideas before students by example can hardly be over emphasized. Such concepts should be encompassed even though the main effort at the undergraduate level is largely restricted to developing the student's ability to master the scientific and technical aspects of engineering education. In what follows, therefore, these disciplines are emphasized even though they are but a portion, although a vital one, of the total education that the successful engineer acquires in college and throughout his subsequent professional career.

Assimilating New Scientific Material

The evolution of engineering curricula has been characterized by a continuous process of assimilation of new scientific and technological knowledge. Such innovations have necessitated the development of new concepts or shifts to more fundamental and scientific approaches. It seems evident that the frontiers of science and technology are now advancing at a more rapid rate than at any previous time, and that many of today's frontiers will be reduced to significant engineering practice in the years ahead. Furthermore, these newly developed frontiers illuminate the older fields with new concepts and give them increased vitality. It is a responsibility of the engineer to recognize those new developments in science and technology that have significant potentialities in engineering. Moreover, the rate at which

new scientific knowledge will be translated into engineering practice depends, in a large measure, upon the engineer's capacity to understand the new science as it develops.

This translation of new scientific developments into engineering practice will be facilitated by emphasizing unity in scientific subject matter. For example, there is a great deal of similarity, both in conceptual undertanding and in analytical methods, among the generalizations of heat flow, mechanics of fluids, electromagnetic fields, and vibration theory. When a student understands these generalizations, he has gained a concept of systematic orderliness in many fields of science and engineering; he is therefore able to approach the solution of problems in widely diverse fields, using the same analytical methods. This unification of methods of analysis can be accomplished to a considerable degree without reaching beyond undergraduate mathematical levels. It can be accomplished to a much greater degree by utilizing advanced mathematical concepts.

Breadth of Engineering Education

Looking at the subject of instructional goals even more broadly, one concludes that the engineer should be a well-educated man. He must be not only a competent professional engineer, but also an informed and participating citizen, and a person whose living expresses high cultural values and moral standards. Thus, the competent engineer needs understanding and appreciation in the humanities and in the social sciences as much as in his own field of engineering. He needs to be able to deal with the economic, human, and social factors of his professional problems. His facility with, and understanding of, ideas in the fields of humanities and social sciences not only provide an essential contribution to his professional engineering work, but also contribute to his success as a citizen and to the enrichment and meaning of his life as an individual. Hence, instructional goals include motivating students and providing them with stimulating opportunities to gain understanding and appreciation of our historical and cultural heritage. This requires that the faculties of the humanities and the social sciences regard the teaching of engineering students as challenging and rewarding, and that engineering faculty members adopt an appreciative and understanding attitude toward their colleagues in the liberal arts.

It is clearly recognized that many engineers progress into managerial and top executive positions in industry and government. For such individuals the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build. This foundation may be built more solidly in humanistic and social courses than in highly applied studies in management.

Education for the profession of engineering does not stop with the acquisition of a degree; it must continue throughout life. Hence, one of the significant instructional goals of engineering education is to motivate the student to learn on his own initiative.

Curricular Areas and Content

The preceding discussion of instructional goals clearly indicates that certain curricular areas are obviously basic to undergraduate engineering education. These areas include mathematics and the basic sciences, the engineering sciences, the application of these sciences to the analysis and synthesis of engineering systems within the student's major field, technical courses outside his major field, and humanistic and social studies.

The following paragraphs describe briefly the more important components of an engineering curriculum and give a rough indication of the broad curricular content and approximate level that appear to be appropriate to an undergraduate curriculum. ***These paragraphs are not intended as a statement of rigid require-***

ments, since the Committee recommends widespread experimentation. However, significant departures from these recommendations should be accepted only on the basis of clearly stated educational objectives.

The Basic Sciences

The basic sciences which make up the foundation of engineering curricula are usually considered to include mathematics, physics, and chemistry. These studies and the level of instruction contemplated in each are discussed below. *In general the basic sciences will total about one fourth of the undergraduate program.*

Mathematics—Casual persual of current professional journals is sufficient to show that all branches of engineering are continually becoming more dependent upon mathematics of an increasingly high level. In fact, engineering judgment is more and more often guided by mathematical analysis, and such analysis is rapidly expanding the demands it places upon advanced areas of mathematics. At the undergraduate level, competence in the theory and use of simple, ordinary differential equations and their application to the solution of physical problems lies close to the boundary of *minimum* acceptability of mathematics in any satisfactory engineering curriculum. For students who will be chiefly interested in research, development, or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary.

A minimum level of performance in mathematics should be established, whether it be obtained in required mathematics courses or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the student's knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency and should be taught by staff members who have this proficiency.

Physics—Too often, physics as presently taught to engineers barely touches upon the many new physical concepts which have been developed during the past generation and which today strongly influence engineering practice. *Modern physics, including an introduction to nuclear or solid-state physics, should be a part of undergraduate engineering curricula.* As a contribution to making this presentation to engineers as effective as possible in a limited time, it is believed that the basic course in physics needs a new orientation. The duplication between classical physics and the engineering sciences of mechanics, thermodynamics, and electricity can be largely removed if the objective of the introductory physics course is redirected to place much greater emphasis upon sub-microscopic phenomena and the conservation principles, with virtual elimination of semi-engineering examples. An introductory course in physics that attempts to be a tool subject for engineering mechanics, thermodynamics, and electricity appears to serve less and less purpose. When engineering colleges request physics departments to present an introductory course in atomic physics for large numbers of engineers, it seems evident that the introductory physics course will then have to be remodeled to provide the strongest possible background for this new objective.

Chemistry—Chemistry should include topics in inorganic, organic, and physical branches presented in condensed and general form. The initial study must prepare engineers to enter advanced courses in chemistry and in its applications to such fields as properties of materials, metallurgy, fuels and combustion, corrosion, and industrial chemical processes. Hence, such subjects as rates and kinetics of chemical change, chemical equilibria, phase diagrams, solutions, electrochemistry, and colloids should be included. Careful coordination should also be effected between modern physics and chemistry. For stud-

ies beyond the usual freshman chemistry course it is felt that physical chemistry deserves the main emphasis.

The Engineering Sciences

An engineering science as defined here is a subject that involves largely the study of basic scientific principles as related to, and as related through, engineering problems and situations. Engineering science stems from two basic areas: mechanical phenomena of solids, liquids, and gases; and electrical phenomena. A common practice is to subdivide these into the following six engineering sciences:

1. Mechanics of solids (statics, dynamics, and strength of materials).
2. Fluid mechanics.
3. Thermodynamics.
4. Transfer and rate mechanisms (heat, mass, and momentum transfer).
5. Electrical theory (fields, circuits, and electronics).
6. Nature and properties of materials (relating particle and aggregate structure to properties).

It is not necessary that this material be treated as separate courses. Experimentation should be encouraged to find the best way of achieving, with the available staff, the desired goal in a specific environment. It is not intended that the above shall be a complete list of the engineering sciences. *It may be anticipated that other engineering sciences will develop;* for example, information theory shows promise of contributing to measurement and control in all engineering fields.

Few existing curricula contain all six engineering sciences, despite wide agreement as to their basic desirability. It is evident that the engineer needs background in all of the six fields listed. Only after careful consideration and determination that the fundamental concepts are substantially covered in other studies at an equivalent mathematical level, should one of these engineering sciences be omitted from a curriculum. Alternately, there may be some curricula or engineering programs for which sciences other than those listed must be chosen, for example, a life science or an earth science. *It should be possible to achieve the breadth, quality, and penetration desired by allotting about one fourth of the total program to the undergraduate study of engineering sciences.*

In the study of engineering science, full use should be made of the mathematics, physics, and chemistry described in the section on Basic Sciences, recognizing that some repetition is a normal pedagogical necessity, but that it can be most effective only when consciously and purposefully used. Perhaps nowhere else can the qualities of a scholarly engineering faculty be employed so effectively as in the presentation of the engineering sciences with an appropriate mathematical understanding.

The Committee is aware that many present curricula do not contain adequate content in each of these fields. The Committee therefore stresses its position that the requirements for engineering sciences suggested above, as well as the requirements in basic sciences suggested herein, represent not only desirable goals, but the actual trend of future education for engineers. The suggested requirements are not intended to be taken as precise criteria for accreditation, although they are intended to be helpful in achieving higher standards for that purpose.

Engineering Analysis and Design

Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, development, and engineering research is the most distinctive feature of engineering curricula. Such education intrinsically stems from the case method of approach, rather than from an orderly exploration of a given subject-matter field. Some experience in this "design" function should be carried in an integrated manner through each semester of the last two years and may be begun earlier if practicable. *Approximately one fourth of the total undergrad-*

uate program may be appropriately devoted to engineering analysis and design, including the necessary technological background.

Among various mechanisms for implementing the case method are theses, projects, group operations, competition between groups, the use of realistic or unsolved problems, examinations on unfamiliar subject matter, and the synthesizing of a new device rather than the analysis of an old one. These case studies go far beyond and are quite different from routine repetitive features of practical design, the use of handbooks, or the description of structures, equipment, or machines, including their construction, operation, and maintenance. Such engineering art is learned more effectively from field experience than from college study. *The capacity to design includes more than mere technical competence. It involves a willingness to attack a situation never seen or studied before and for which data are often incomplete; it also includes an acceptance of full responsibility for solving the problem on a professional basis.*

This portion of many engineering curricula demands close scrutiny and continuing active change. The major department sequences in many instances are dull and uninspiring, utilizing practices long outdated. These are areas in which newly developed concepts, analytical techniques, and measurements should be brought to bear. They should be taught by men who are making active contributions to engineering progress. For example, courses in Internal Combustion Engines are often largely descriptive in nature, and hence are essentially sub-professional. They can be vital experiences in which the principles and advanced analytical techniques of mechanics of solids and fluids, thermodynamics, and heat transfer are used effectively; the nature of combustion, friction, and materials are considered; and creative thought and imagination are brought to bear in producing an integrated system. To do this is a difficult and challenging job, but a very necessary one. These observations apply with equal force to such subjects as Power Plants, Highway Engineering, Electrical Machinery, Chemical Processing, Extractive Metallurgy, etc., etc. It is important again to stress the necessity of utilizing fully in such studies the basic and engineering science training at the level which this report outlines.

Engineering Laboratories

The laboratory is the means of teaching the experimental method. It should give the student the opportunity to observe phenomena and seek explanations, to test theories and note contradictions, to devise experiments which will yield essential data, and to interpret results. Therefore, laboratories should be used where and only where these aims are being sought. The value of a set number of stereotyped experiments is questionable. The development of a smaller number of appropriate experimental problems by the students themselves under effective guidance will have much greater educational value.

The art of measurement—including analysis of accuracy, precision, and errors—and the appreciation of the degree of accuracy economically justified, together with some understanding of statistical methods, are essential elements of laboratory experience.

Laboratory reports, when restricted to a few per semester, present a major opportunity to develop skill in the written presentation of engineering information. Stereotyped reports are valueless in teaching the art of communication.

Non-Departmental Engineering Courses

Such courses as electrical engineering for non-electricals, heat engines for non-mechanicals, etc., should emphasize fundamental ideas and principles and methods, rather than special machines or devices. *The most important engineering background of the professional engineer, apart from his major field, lies in the basic sciences and the engineering sciences.*

The study of engineering materials, in-

cluding laboratory testing, is often scattered through several courses and can be coordinated to advantage. Increasingly, forward-looking engineers are searching the recent advances in solid-state theory and chemistry for an entirely new and fundamental scientific approach to the study of the behavior of materials. This field appears to be almost ready for engineering conquest, and its development will bear very close watching by engineering educators.

Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful for these purposes is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, and the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work. Though the engineer may only supervise the preparation of the drawings required to execute his designs, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with graphical communication.

Shop courses and all other courses emphasizing practical work that tend to displace engineering science in the curriculum should be scrutinized critically in the light of the instructional goals already discussed.

Humanities and Social Studies

The goals of engineering education already outlined require for their achievement adequate attention to subjects in the humanistic and social fields. In addition to technical knowledge and skill, the professional engineer needs to have some acquaintance with the subject matter of fields other than his own, with their influence upon the lives of men, and with their relationships to his own profession.

If the student is to be provided with a foundation upon which he may build a career of professional stature, his education must help him to seek his fullest development as an individual. This involves stimulating his imagination, instilling a respect for learning in all its forms, and creating an awareness of the great variety of ways in which man has sought order and meaning in the universe. College experience should facilitate the student's growth in ability to perceive significant relationships, to make intelligent value judgments, to express himself with ease, clarity, and good taste, and to develop the qualities of character and personality requisite for a successful career.

To the attainment of these objectives both the technological and the humanistic divisions of the curriculum should contribute as integral parts of one total program. It is a mistake to look upon technology alone as the productive component of the student's development and on the humanities as providing only the liberalizing elements in his pattern of growth. On the contrary, all of his courses of study, whatever their specific objectives in knowledge or skill, should be so designed and taught as to contribute toward the student's development as a truly educated man whose convictions, understandings, manner, and speech are intimately related components in the fibre of his life.

To serve most effectively their objective of giving breadth to the student's understanding of the world in which he lives and of awakening his interest in the great ideas that have evolved during man's struggle toward a better civilization, courses in the humanities and social studies should help the student to arrive at a satisfying personal philosophy rather than to provide him merely with immediately useful technical knowledge and skill.

Selection of Courses—The fields of humanities and social studies from which some courses must be selected include history, economics, and government, wherein knowledge is essential to competence as a citizen; and literature, sociology, philosophy, psychology, and fine arts, which afford means for broadening the engineer's intellectual outlook. The Committee has

found no reason to disagree with the recommendations of previous ASEE Committees that *about one fifth of the curriculum should be devoted to humanistic and social studies.*

Such non-engineering courses as accounting, management, industrial finance, marketing, and personnel administration may well be valuable components of a particular curriculum, but being essentially technical in content, they do not adequately fulfill the main purpose of the program in humanities and social studies.

Motivating the student to learn on his own initiative is as much the aim in the humanities and social studies as it is in other parts of the curriculum. In the time available he cannot be expected to acquire a comprehensive knowledge of the subject matter of even one of the humanistic or social disciplines. He can, however, be given an understanding of the nature and function of some of the principal disciplines, together with an introduction to the methods of thinking likely to be most conducive to further growth in these fields within the life experience of the student. The courses should be designed to liberate him from provincialisms, whether geographical, historical, or occupational, and to give him a sense of the satisfactions that he can gain later in life by adventuring more deeply into the areas of critical and creative thought represented in the humanities and social studies. His capacity to make sound qualitative judgments should be developed so that he may distinguish that which is good from that which is mediocre.

English—A word must be said here about English, which is both utilitarian and humanistic. Facility in expression, written and oral, is a professional necessity and an overall personal asset. Knowledge of literature and the ability to read with sympathetic understanding are parts of a liberal education. English, therefore, has one root planted in the humanistic portion of the curriculum, another in the technological. For developing skill in English usage sufficient for the professional engineer, sole dependence upon specified courses is not enough. Adequate motivation is essential; it can be attained only by active efforts on the part of all teachers to point out the economic and cultural rewards which will accrue to engineers who develop skill in the art of verbal communication. This requires personal counseling and sympathetic understanding of the student's pre-college cultural background, as well as insistence on the highest attainable standards of performance in written and oral work in the engineering courses.

Realization of Broad Social Objectives—To realize the overall objectives of the undergraduate program, a reasonable portion of the curriculum, such as a sequence of courses throughout the undergraduate years, should be allotted to formal courses in the humanities and social studies. But this, in itself, is obviously not enough. Members of the engineering faculty can make their own contributions to the general education of their students by precept and example, by their attitudes toward the work of colleagues in fields other than their own, by their support of the various extra-curricular activities that help so much in the maturing of an undergraduate, and by being themselves responsive to a broad range of cultural interests. An engineering faculty member who disparages the value of humanistic courses can hardly expect students who look to him as their ideal to enter upon such studies with enthusiasm.

Teachers on the liberal arts faculty should distinguish between the mission of developing scholars and conducting research in their own disciplines, on the one hand, and their obligation, on the other hand, to make available the knowledge and values that are significant for students majoring in other fields. This Committee believes that no effort to enhance the value of the humanities and social studies will yield greater returns than that devoted

to bringing about a genuine community of interest, better understanding, and more meaningful cooperation between teachers of engineering and those in the liberal arts. The whole field of engineering education is the joint enterprise of men in a variety of disciplines. For it to be effective and complete, they must respect and sustain each other.

Elective Courses

All too often present curricula leave no time for electives, either technical or humanistic. *The Committee believes that provision for electives should be made to an extent of about one tenth of the program exclusive of ROTC.* It also believes that there is an advantage in permitting some students to concentrate such elective study in science, while other students may choose electives largely in humanities and in social fields. The limiting of elective study to courses in the student's major engineering department is not consonant with the objectives being sought.

The Committee on Evaluation recognizes, as do most faculty members, that there is need for as much flexibility as possible within the framework of a given curriculum for each student to extend his own interests. Some choice may exist in the sequence of social and humanistic courses, in the later courses in mathematics and science, and in the departmental sequence of work in engineering analysis and design. However, it is primarily in elective courses that the student can best extend his interest toward his future professional activity. The objectives of engineering education are best satisfied when each student is given a free choice of options or elective courses, provided that the elected courses contribute to a planned objective.

Making Room for New Curricular Material

In this Report, several additions to curricula have been recommended without suggesting corresponding deletions. More emphasis on fundamental science, on engineering science, and on the broad humanistic and social areas has been recommended than is contained in most engineering curricula. This does not imply that the engineering student needs to be worked harder. Indeed there is considerable doubt as to whether there is any margin of student time left. Four possibilities for achieving these additional, important objectives are listed below. Each school, no doubt, will wish to choose its own methods, recognizing that those suggested are of varying degrees of practicability to each institution.

These four are as follows:

1. Raise the requirements for entrance. This might entail:
   a. More adequate high school preparation.
   b. Higher selectivity.
2. Increase the effectiveness of instruction.
3. Eliminate some of the material now in the curriculum.
4. Extend the curriculum to more than four years.

Much has been written about high school preparation. Continuing encouragement should be given to high schools to raise their standards and to give appropriate training to college-bound students, including engineering students. However, it is doubtful whether engineering educators can realistically entertain serious hopes for substantial gains from this source over any short period of time. One ray of hope lies in the summer programs for high school science teachers that engineering schools, with the cooperation of industry, have been offering. Although higher selectivity would permit a more rapid rate of academic progress, it would decrease the number of applicants at the very time when national welfare calls for the reduction in the present shortage of engineers.

Increasing the effectiveness of instruction is a process more or less continuously under study by many faculties. Newer, simpler ways of looking at complicated

phenomena and their analysis evolve continually in the minds of an alert faculty. Profound understanding of a topic is often accompanied by the ability to give a clear and simple statement. One contribution of our graduate schools to the development of undergraduate education should be a continuous simplification in methods of presentation of subject matter to undergraduates.

Elimination of Curricular Material—Elimination of material now in the curriculum, likewise, is an accepted practice in rapidly growing fields. Two kinds of material can well be looked at with a view toward possible elimination. Unduly repetitious material should be eliminated. Conscious repetition, carefully designed as a pedagogical instrument, may be used but not to the extent that it detracts seriously from student interest. Other areas due for close scrutiny, with a view toward possible elimination or reduction in time, are those courses having a high vocational or skill content and those primarily attempting to convey engineering art or practice. *Some attention to engineering art and practice is necessary, but its high purpose is to illuminate the engineering science, analysis, or design, rather than to teach the art as engineering methodology.*

A review of the evolution of engineering curricula over many years shows a trend toward increasing emphasis on the science underlying engineering at the expense of the study of engineering art for its own usefulness. This trend would appear sound for application in the present dilemma.

Thus, the Committee feels that the most promising possibilities of finding time for increased emphasis on fundamental science, engineering science, and humanistic or social studies are (1) elimination of some of the present curricular material and (2) increased effectiveness of instruction. If these criteria for elimination of material of a high vocational or skill content are applied rather forcefully by engineering faculties, it is felt that opportunity will be found within the usual time limits to increase basic studies as indicated in this Report. This will not be achieved, however, by repair of patchwork curricula. It requires complete reconstruction of curricula.

The Committee, after careful consideration, takes no position with regard to the length of the program. It believes, however, that further experimentation is called for in all four of the means suggested for introducing new curricular material.

Evolution of Engineering Curricula

The great changes in physics and chemistry over the past thirty years and the equally great advances in engineering practice do not seem to have produced an equivalent counterpart in a reorganization of engineering curricula. A group of industrial advisors to the Committee has pointed out that the problems in production and manufacturing are now demanding greater and greater scientific background for engineers. As one example, emphasis was placed upon automation as a current problem of the machine designer. The need for such instruction is critical in certain industries, and several of these offer such courses to their personnel. If this is generally true, engineering education may be a decade late in giving emphasis to electronics in the curriculum of mechanical engineering or in teaching applied electronics as a part of machine design.

Unchanging Factors in Curriculum Design

It is relatively easy to look backward and recognize changes; it is more difficult to visualize what lies ahead. After facing many questions regarding the future of engineering practice, one is likely to conclude that the teaching of practice, as it exists today, will always be of limited use because the graduate is certain to find practice changing from year to year. And, as a matter of fact, the engineering art taught in colleges will normally reflect

practice that is already obsolete in part, since the teacher's knowledge of practice becomes rapidly outdated.

But fortunately, some things do not change. Reactions, stresses, and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics, and heat flow will be as important to the next generation of engineers as to the present one. Solids, fluids, and gases will continue to be handled, and their dynamics and chemical behavior will have to be understood. The special properties of materials as dependent upon their internal structure will be even more important to engineers a generation hence than they are today. These studies encompass the solid, unshifting foundation of engineering science upon which the engineering curriculum can be built with assurance and conviction.

Attitudes of Engineering Faculties

The problem that faced the Committee on Evaluation of Engineering Education soon after its organization was to think through the implications of the steadily increasing importance of the engineering sciences upon curriculum design and upon faculty, students, and employer relations. The questions to be answered were of the following nature. Would faculties believe that much stronger emphasis upon the engineering sciences and the basic sciences will produce only research men? Would the employer be pleased with graduates of such programs or would he prefer men able to earn their salary immediately upon graduation without special job training? Could students undertake a more scientific program without excessive failures?

Not knowing the answer to these questions, the Committee suggested in its Preliminary Report the concept of bifurcation as a possible means of transition from the present curricula, which are largely of the general professional category, to the strong scientifically oriented curricula that it visualized as being required for an unknown, but in no sense negligible, percentage of future graduates. As defined in the Preliminary Report, the scientifically oriented curriculum included increased emphasis upon mathematics and physical science, the engineering sciences as previously described, and a two-year sequence of courses in engineering analysis, design, or the study of engineering systems.

The discussions of the Preliminary Report which were forwarded to the Committee by the colleges of engineering established a reasonably clear viewpoint. This concensus of engineering faculties consisted of three parts: (1) a strong support for higher standards of accreditation for engineering education but not for designation of especially meritorious curricula, (2) a nearly universal institutional reaction that engineering curricula should not be subdivided into two functional stems but a recognition of the usefulness of functional variation at the top, and (3) a growing desire for a deepening and broadening of basic science content throughout all engineering curricula.

Viewpoint of Employers

After receiving this expression of attitudes from the engineering institutions the Committee determined to learn something of the viewpoint of employers. At a meeting in Atlanta, Georgia, in February, 1954, seven of the largest employers of engineers were invited to advise the Committee. These organizations employ all types of engineers in all functions from research to sales and construction. In fact, most of the organizations represented employ only a small fraction of their engineers in research, development, and design. On the average less than twenty-five per cent of their engineers work in these fields. One company has most of its engineers employed in operation and another in manufacturing. A third has one of the largest construction organizations in the country. Several employ nearly one half of their engineers in sales. Nevertheless, the industrial repre-

sentatives who were present concluded that they would prefer nearly all of their engineers to be trained in scientifically oriented curricula.

The industrialists emphasized that their sales, manufacturing, operation, and maintenance engineers need strong scientific backgrounds just as much as do their research and development engineers and their designers. They were unwilling to sacrifice courses in engineering sciences to provide time for the study of technology or administration at the prebaccalaureate level, since they believe that these can be obtained under company sponsorship when needed.

Initially the industrial advisers to the Committee represented only large employers. Therefore, the Committee requested one of the companies to make a survey of a number of smaller organizations at the operating and manufacturing level. The returns indicated no criticism of the technical competence of engineers but raised questions concerning (1) the adequacy of their background in basic science, engineering science, and humanistic fields and (2) concerning their capacity for effective communication. This reaction with regard to the inadequacy of basic science and cultural background was essentially unanimous.

Abilities of Engineering Students

The Committee on Evaluation has also given consideration to the question whether a stronger emphasis upon basic science and engineering science would lead to increased failures in completing engineering curricula. Some who have experimented in this direction give assurance that this common assumption is not necessarily true. The best authority to the effect that engineers can handle additional work in basic science and engineering science without undue difficulty lies in the results of national tests. These indicate that at both the undergraduate and the graduate levels, engineering students show the same high level of mental ability as students of the physical sciences. It seems reasonable to conclude, therefore, that the principal groups of engineering students will prove able to complete whatever type of curriculum the profession of engineering considers necessary preparation for its prospective members.

Opportunity for Scientifically Oriented Curricula

The consideration of curricula cannot proceed wholly on a philosophical or qualitative basis but must eventually be approached quantitatively in semester hours or at least in terms of fractional percentages of the total program. The Committee on Evaluation, in order to clarify for itself the practicability of its suggestion that curricula of the usual type can be designed with an enhanced scientific orientation, has developed for consideration the broad outline of scientifically oriented curricula. *It intends this skeleton curriculum to be considered as suggestive rather than restrictive. The great need of engineering education at this time is for experimentation with, rather than standardization of, curricula.*

In defining an engineering curriculum the Committee on Evaluation has first indicated the need for *mathematics through differential equations;* however, another application of calculus, such as mathematical statistics and probability, might fit more effectively into industrial or sanitary engineering. Nevertheless, for many existing curricula this means at least one additional course in mathematics. The recommendation that *physics should be extended through an introduction to modern physics* will require more than the usual eight semester hours of sophomore physics, even though some time may be saved by elimination of problems involving semi-engineering applications. There is a growing belief that *some acquaintance with organic chemistry and a working knowledge of physical chemistry is essential to all engineers* and that this objective can not be accomplished within the usual course in freshman chemistry. For most curricula these changes in mathe-

matics, physics, and chemistry would probably require a total of at least six semester hours of additional study.

The second major factor in the original definition of scientifically oriented curricula included nine engineering sciences in sufficient strength to justify their separate listing. *These have now been regrouped into six engineering sciences:* (1) mechanics of solids (statics, dynamics, and strength of materials), (2) fluid mechanics, (3) thermodynamics, (4) transfer and rate mechanisms (heat, mass, and momentum transfer), (5) electrical theory (fields, circuits, and electronics), (6) nature and properties of materials (relating particle and aggregate structure to properties). *These titles should be regarded as generic and broadly definitive rather than as representative of courses now being offered.* In regrouping the engineering sciences into six categories, the Committee made no reduction in the minimum time considered appropriate for their study, which represents one quarter of the engineering curriculum.

The third major element in the definition of an engineering curriculum is that it must contain an integrated sequential study. By this is meant that mathematics and the basic science shall be used proficiently in the courses in engineering science and that the latter, in turn, shall be used proficiently in engineering analysis, in the study of engineering systems, and in the preparation for creative design work. For the scientifically oriented approach it seems desirable that analysis, synthesis, and creative design cover four successive semesters at an intensity to be represented by five or six semester hours per semester.

In addition to basic science, engineering science, and engineering analysis and design, allowance may be made for a minimum three-credit-hour humanistic or social science course each semester for at least seven or eight semesters and also for a small amount of required technology. The general outline of any scientifically oriented curriculum may therefore be described in five blocks of courses under the following headings: humanistic and social studies, mathematics and basic sciences, engineering sciences, engineering analysis and design, and electives.

SUMMARY OF TIME DISTRIBUTION FOR SCIENTIFICALLY ORIENTED ENGINEERING CURRICULA

	Proportion of the Curriculum
(1) Humanistic and Social Studies (Pages 39–41)	*About one fifth*
(2) Mathematics and Basic Sciences (about equal weight) (Pages 36–37)	*About one fourth*
(3) Engineering Sciences (Page 37)	*About one fourth*
(4) Sequence of Engineering Analysis, Design, and Engineering Systems, Including the Necessary Technological Background (Pages 37–39)	*About one fourth*
(5) Options or Electives in (a) Humanistic and Social Studies, (b) Basic Science, (c) Engineering Science, (d) Research or Thesis, (e) Engineering Analysis and Design, (f) Management (Page 41)	*About one tenth*

It will be noted that the fractions given do not total exactly one-hundred per cent. Hence, it should be evident that the Committee does not desire this suggested distribution of emphasis to be restrictive. There will be many reasons for variations among institutions and among departments of a single institution. *Experimentation is strongly encouraged.*

In the above table, items (1) through (3) consume about seven tenths of the curriculum. They define an area of common orientation which the Committee regards as essential to a unity of understanding by students in different engineering fields. There is no reason why such unified understanding can not be achieved by somewhat different courses, with dif-

ferent instructors. It will not be achieved, however, if technology is substituted for basic and engineering science or if courses with names from fields of engineering science are presented merely as a necessary sideline to the objective of teaching current practice.

The Committee's interest in the curriculum outline above is centered in: (1) the indication that the concept of four-year curricula with scientific orientation is practical, (2) the indication that considerably more than the usual "common freshman year" is an evolutionary result that could accompany scientific orientation of curricula if desired, (3) the opportunity presented by elective study for meeting the interest orientation of students and the functional needs of engineers engaged in research and design as well as in management and construction.

Special Factors that Influence Undergraduate Educational Achievement

Student Selection and Advanced Standing

It is recommended that high school students interested in engineering be encouraged to prepare themselves adequately for engineering work in high school by developing proficiency in the use of English and mathematics and by gaining an understanding of science, particularly physics and chemistry. A most effective way of so encouraging these students is to make proper adjustment in the work required of them in engineering schools. This may be done by allowing college credit for previous work, or, if this is undesirable, by making the credit hours required for graduation flexible and dependent upon the preparation and skills of the entering student. A student should not be required to repeat work in college if he is adequately prepared by work already covered or by proficiency previously acquired in high school or elsewhere; instead he should be allowed to proceed into more advanced work. When so excused from taking a specific course on the basis of previously developed proficiency, he should not be required to substitute other work not demanded of other students, for this requirement always discourages students from presenting advanced work for entrance. *However, proficiency should be determined by examination and should not be assumed because of the acquisition of high school units beyond those required normally for admission.*

Requirements for admission to an accredited engineering curriculum must of necessity be rather rigorous to insure adequate capability of the student to pursue engineering studies in an orderly and effective manner. The Committee, therefore, recommends the following minimum requirements for admission:

1. Graduation from an accredited secondary school, or demonstration of equivalent education.
2. Demonstrated capacity for satisfactory achievement in engineering.

It should be recognized that the minimum requirements listed above impose great responsibility upon directors of admission for proper selection of students for engineering colleges, especially when the availability of required courses in the various high schools is taken into consideration. Such students should normally accumulate at least three units of English, four of mathematics, and at least one unit of physical science if they are to make satisfactory progress in engineering schools whose curricula are organized on a high professional level. Furthermore, unless suitable screening techniques are applied, such students should stand in the upper quarter of the overall integrated group of high school graduates. It is suggested that pursuit of vocational courses should be discouraged as preparation for engineering and that not more than two of the sixteen units for entrance should be considered from drawing, shop, or other vocational work. Additional background in mathematics, science, and humanistic and

social courses is of far greater benefit to the student.

The Committee also recommends that colleges should:

1. State their requirements for admission clearly.
2. Elect to admit students with deficiencies only when there is strong evidence to indicate probable success in engineering and always state clearly what those deficiencies are and how they may be removed.
3. Maintain records of criteria used to determine admission.
4. Use such records to improve the screening process.

Students transferring from accredited junior colleges, liberal arts colleges, or other engineering colleges should be admitted on a provisional basis; the final transfer of their credits should be delayed until their subsequent records indicate maintenance of the achievement level required for graduation. A realistic evaluation of credits presented for advanced standing should be made on the basis of course content or a proficiency examination rather than on an inflexible basis of equivalent credit hours.

High School-College Articulation

As preparation for engineering education there is no substitute for scholarly levels of instruction in high school with adequate emphasis upon developing both interest and reasonable proficiency in mathematics, English, physics, and chemistry. The Committee on Evaluation believes that a great deal can be done to improve the scholarly quality of education offered in the high schools. This can best be accomplished by developing close working-relationships between engineering colleges, high schools, and ECPD guidance committees at the local level. The ECPD Committee on Guidance should be encouraged to extend its activities in this direction. Some engineering colleges have developed conferences and educational programs, jointly participated in by high school and college teachers. Several industries have provided the financial support for such educational programs. These programs can be highly effective in giving high school teachers an insight into the nature of the scientific and mathematical preparation which is needed by students who plan to study science or engineering in college.

In order to encourage high school-college articulation, it is recommended that a study be undertaken by ASEE in cooperation with professional and industrial groups and societies representing mathematics and the pure sciences for the following purposes:

1. To determine specific techniques for identifying, encouraging, and developing those high school students who have aptitudes for engineering or science.
2. To determine methods for developing adequate study habits and a suitable level of performance in reading ability for those students planning to attend college.
3. To develop specific techniques of reaching high school faculties and administrators in order to enlist their cooperation in a constructive program to improve the quality of high school preparation, particularly in mathematics, physics, chemistry, and English.
4. To determine, at each university engaged in teacher training and having a college of engineering, ways of providing advanced study as a part of high school teacher education that would make such teachers more proficient instructors in the subjects necessary for admission to engineering.
5. To develop specific techniques for presenting these problems and their possible solutions to high school administrators, teachers, and the general public.

Providing Opportunities for Gifted Students

Leading engineering educators have long felt that the standardization of engineering curricula in the United States has provided too little opportunity for outstanding students with creative talents

to develop these capacities at the greatest possible rate. Most courses are organized to proceed at a rate that can be followed by the average and, commonly, by the below-average student. At some place in the undergraduate program there should be an opportunity to break this "lock step" and permit the student full play of his intellectual and creative powers.

The Committee is aware of three possible methods for providing such opportunities. The first is the special curriculum, designed both in content and in method of administration to challenge adequately the exceptional group at the top of a class. The second method is that of permitting the exceptionally able student to elect his program widely with due precautions against excessive specialization; to carry as heavy an academic load as experience indicates he can handle; and, in general, to let him build out of the courses that may be available, including in special cases appropriate graduate courses, a program that stimulates and challenges him. The third method, and the one that philosophically has the greatest appeal, is that of giving the student a great degree of personal freedom to study individually under general supervision and guidance in whatever way appeals to him as being most effective in his individual case. Combined with this, of course, must be a rather infrequent but very searching examination designed to provide an overall measure of his accomplishment and to test his level of understanding in a broader and yet more penetrating way than the usual term examination.

The first and second methods—that is, the special curriculum for a gifted group and the individually elected curriculum, respectively—are in regular practice at various institutions in the country. Any adviser, if he is given freedom to adjust the curriculum, can adopt the second method whenever he recognizes among his students one who is capable of benefiting from such a program. While the results of such procedures are extremely difficult to measure with any degree of certainty, the evidence is not unfavorable.

In the case of the third type of program, however, experience in engineering in this country has not been conspicuously convincing. One difficulty is that, given a large measure of freedom as to place, method, and program of study with only the most general sort of restraint in the form of comprehensive examinations at the end of one- or two-year periods, very few students will absent themselves from rather regular classroom exercises if these are handled in a reasonably interesting and inspiring manner. Class exercises are an exceedingly effective way of acquiring basic, scientific disciplines. Other students who take seriously the admonition to study independently have often found that they lacked the necessary self-discipline to achieve the same intensity of intellectual effort and actual accomplishment as that achieved by the regular student. This has sometimes been revealed discouragingly when such a student has later been faced with the searching doctoral examination in which demonstrations of relatively elementary ideas, but at a profound level, have been required. The student who has enjoyed complete freedom under general guidance has often failed to acquire the degree of exacting mastery of basic principles that is expected.

The brilliant student who becomes the personal protege of a wise and able professor, however, may attain extraordinary achievement under a free program. This rather rare student is obviously an exception to all rules, and the perceptive and wise faculty member will break many rules in order to allow him to develop his own initiative and ideas. Such students will set their own courses in life, faculty members notwithstanding, and they do not constitute the problem being considered here. The adequate social development of such individuals, however, may be a serious problem. Intellectual development and social development are interrelated; hence, one cannot be accelerated and the other ignored.

It is, therefore, the rather select group found in the top ten per cent of a good class with whom faculties should be more concerned. There are, of course, many ways in which the monotony and tedium of the highly organized classroom course can be relieved for these students. The privilege of joining faculty societies of scholars should provide exhilarating motivation in this direction. Such students should be given individual encouragement that will help stimulate them to something beyond the ordinary performance. In the United States there is a great need for continued experimentation in the search for the solution that apparently is still to be found for this important problem. The European solution, although excellent in its natural setting, has not proved susceptible to direct transplantation to this country. The strongest encouragement should be given to those teachers and administrators who would like to experiment in increasing the responsibility of gifted students for their own education.

Foreign Students

The foreign student brings both assets and problems to an engineering school in a ratio that can be greatly influenced by wise administration. Also, our world obligations place a responsibility upon us to make the foreign student's experience valuable to him in terms of the problems and opportunities he faces when he returns home.

Credentials of foreign universities are often difficult, if not impossible, to evaluate in terms of American standards of admission. Hence, internal placement examinations are sometimes necessary. There are difficulties the foreign student experiences in adjusting himself to the university in terms of language and cultural tradition. Insistence upon reasonable facility in conversational English is, therefore, essential. There may also be serious financial problems.

The foreign student who is well prepared is likely to be well advanced in theory but inexperienced in laboratory procedure. Sound programs for such a student will recognize these facts.

ROTC Credit

The Engineering Colleges recognize their obligations to the nation to train through the mechanism of ROTC a supply of future officers for the Armed Forces. It is believed that this should be accomplished without compromise with the basic educational concept developed in this Report.

The Military Affairs Committee of the ASEE, at the request of the Committee on Evaluation of Engineering Education, made a survey to determine the credit being allowed currently for advanced ROTC courses and what credit was considered reasonable. The replies made it clear that the majority of engineering colleges do not recognize advanced ROTC as an appropriate substitute for engineering courses. However, an average of about six credit hours is being accepted as a substitute for humanistic and social studies. More than fifty per cent of the engineering colleges do not allow credit for advanced ROTC as a substitute for engineering courses, and about twenty-five per cent do not allow credit toward humanistic and social science courses.

The Committee on Evaluation recommends that no credit be allowed for advanced ROTC courses as a substitute for engineering courses. The Committee also looks with apprehension upon appreciable substitution of ROTC credit for humanistic and social studies. Although the context of certain ROTC courses may involve geography and government, fundamental differences exist between these courses and those offered in the humanities and social sciences.

The major differences in course objectives, course organization, and qualification of instructors are valid reasons why the ROTC courses generally cannot contribute in a major way to the professional and liberal education of an engineer as do the other courses in the curricula. Ideally, no substitution of ROTC credit should

be allowed either for engineering courses or for those in the humanities and social studies. *As a practical matter it is urged that substitution of advanced ROTC credit for humanistic and social studies alone should not exceed one quarter of the total credit allotted to this area.* Experiences in a wide range of institutions demonstrate that the advantages to the student of ROTC training are sufficient to attract his enrollment without diluting his professional and cultural education through granting academic credit for ROTC beyond the amount proposed.

Graduate Study in Engineering

The growth of graduate study in engineering in the past two or three decades has been remarkable.[1] Both statistically, and in the minds of those concerned with engineering education, graduate study has become an element of such major importance that it necessitates serious attention in any evaluation of engineering education.

The need for post-baccalaureate study by those who are to advance our highly complex technology is generally recognized. The four-year program, even with increased scientific emphasis, simply cannot provide the depth and breadth of scientific foundation and the background for creative thinking in design which are needed. *The need for graduate education varies with the rate of advance in the use of science characterizing various fields of engineering; it is greatest in those fields in which this rate is most rapid or to which science can contribute most directly.* Industry places a substantial value upon graduate education, as indicated by recruiting efforts, salaries, and advancement to positions of high degrees of responsibility. Furthermore, as is implicit in this Report, engineering education must be based more and more on a profound knowledge of the basic sciences and so will require that an increasing proportion of its teachers will have the benefit of advanced graduate education. It is obvious, therefore, that educational institutions with *adequate* resources to support good graduate work in engineering have not only an opportunity but also an obligation to attract and develop as many well-qualified graduate students as possible. Those educational institutions which operate solely on the undergraduate level have also an obligation to participate by preparing and encouraging their students to take graduate work elsewhere. Many small schools have made impressive records in furthering graduate education in this way. Even institutions having well developed graduate programs should encourage their better students to enroll in other similarly qualified institutions for graduate study because of the educational advantages to the student of new scholastic environments and different personalities among their instructors.

It is traditional for institutions of higher learning to serve two ends: disseminating and extending learning—that is, education and research. It is common to distinguish three separate yet closely related activities: undergraduate education, graduate education, and fundamental research. When these are maintained in adequate balance and properly correlated, each can enormously strengthen the other two. One kind of correlation that is very effective is attained by having faculty members who wish to engage in all three activities.

Objectives of Graduate Study

Although one conception of the purpose of graduate study is that of increased specialization in a narrow field, the Committee feels that a broader conception, developed as discussed below, is more significant. For example, the topics in organic and physical chemistry or in solid-state and nuclear physics, which seem so essential to one "specialized" graduate program in engineering, will be almost

[1] See, for example, "The Growth of Graduate Study in Engineering," by Henry H. Armsby, *Journal of Engineering Education*, Vol. 45, No. 3, 1954, pp. 220–227.

exactly duplicated in many others. Graduate study in engineering thus has a broad common base in science and mathematics. Such concentration as may be desirable, for example on a thesis, should be undertaken with the objective of developing breadth of understanding and capacity to solve difficult problems. Naturally the student who studies intensively in one particular field possesses a ready skill in this special area which may have immediate utility. Such facility, however, has only a temporary value without the overall intellectual growth through which the individual can master new techniques in any of numerous fields. *The acquisition of techniques is, therefore, incidental in graduate educational experience, the deepening of insight and understanding, and the development of the stronger intellectual and scientific foundations that are required for real mastery of the field involved.*

Hence, the objectives of graduate study in engineering are the development of (1) a more general and fundamental understanding, not only of the sciences specifically underlying a particular field, but also of those underlying related fields; (2) more general and more powerful methods of analysis; (3) capacity to read with understanding the advanced work, classic and contemporary, through which the field is advancing; and (4) courage, imagination, and technical capacity to make new advances and to know the methods, as well as the failures and successes, involved in such advances.

A recognized objective which is being implemented at a few institutions is that of continuance of general education outside the fields of engineering and science at a serious and mature level. This is particularly important for those who expect to become engineering teachers. The growing broad responsibilities of all engineers further justify increasing attention to this objective. Culture can, of course, be acquired by penetrating self-study in a variety of fields or assimilated by close association with scholars. Its acquisition is seldom neglected by those who are regarded as leaders in their own fields, nor can it be by those who would live a complete life.

Requirements for a Strong Graduate Program

The essential requirements for a strong graduate program are few, simple to state, but difficult to achieve. They are: (1) a specially qualified faculty, (2) students of superior ability, and (3) adequate administrative and financial support. Without each of these requirements, graduate work worthy of the name is impossible. Given these characteristics, such elements as curriculum, requirements for degrees, laboratory facilities, sustaining research programs, library, student housing, associations with the leading national and international centers in the field, and intercourse with related and underlying fields of learning and research can be expected to evolve. Each of these three requirements is examined in some detail below.

The Graduate Faculty—To an even greater extent than in undergraduate education, an outstanding faculty is the single most important requisite for successful graduate work. As emphasized in the section on the Selection and Development of an Engineering Faculty any good teacher must have drive, enthusiasm, judgment, and a sincere interest in the development of men. Although it is not possible to draw up a set of rigid specifications for a graduate faculty, the following characteristics are among those common to many outstanding graduate teachers in engineering:

1. A creative talent and a receptiveness to new ideas which manifest themselves in the constructive use of new knowledge.
2. A fundamental and critical understanding of one or more fields of engineering.
3. An ability to relate knowledge and experience in one field to a total concept involving many fields of endeavor.
4. A high intellectual capacity and an

insatiable desire to learn and to understand.

5. A profound understanding of the basic sciences, including mathematics, as they relate to engineering.

The full development of the qualities listed above means that the successful graduate faculty member is either actively contributing to the frontiers of knowledge or is engaged in applying new knowledge successfully to the solution of challenging situations. The graduate faculty member should enjoy teaching. He must desire to transmit his evergrowing knowledge and understanding and urge for intellectual growth to young people. In his teaching, however, he should deal with students as colleagues, rather than as pupils, whether in the classroom, office, or laboratory. This obligation to the student cannot be fulfilled properly unless the teacher is doing creative work.

The strong faculty is composed of a group of men of diverse talents and interests who are dedicated to the overall objective of providing the stimulation and environment for the professional growth of themselves and their students. Many members of the faculty teach both undergraduate and graduate students. This is desirable, but the nature of the tasks and attitudes in teaching advanced subjects must necessarily be somewhat different from those in undergraduate teaching.

The graduate faculty deals with a student body comprising a selected group of the best students who have completed an undergraduate course of study and have indicated a keen interest in preparing themselves for high-level professional work. While many such students are interested in research, development, and creative design, the rapid growth of technology is also creating demands for men trained at the graduate level to employ greater understanding in the solution of problems in the area of production, management, etc. There is good evidence that the best graduate education for these differing functions in engineering is one that will develop the intellectual capacity of the individual rather than high specialization toward a given functional objective.

Faculty-Student Relations—Because of the close associations that are typical of graduate work, graduate teachers have an opportunity to know their students well and to provide the individual inspiration and leadership that is an essential part of the graduate environment. Moreover, this relationship properly used insures that the student is impelled to take the initiative and to work on his own or as a full-fledged partner without undue assistance. *Nevertheless, the wise teacher recognizes the great transition involved in movement from undergraduate to graduate study and accepts responsibility for exerting the skillful leadership needed to bring the student quickly to the stage of independent study.*

Though interested in developing student competence and enthusiasm in his own field, the good graduate teacher stimulates student interest in many fields. Such teachers are on the alert to detect evidence of imaginative and creative thought and to give the encouragement and support necessary to bring such ideas to full development.

The Graduate Student—A faculty having the requisite abilities for conducting a graduate program will insist that the graduate student body be intellectually and temperamentally qualified for graduate level work. First-rate graduate work makes substantially greater intellectual demands than undergraduate work. It also demands more in imagination, in self-reliance, and in capacity for independent work under less specific guidance.

Because of the greater dependence of success upon centered interest and intellectual outlook and character, the selection of graduate students must depend upon individual appraisal. Certain general guides are, however, widely used. Not all of those who receive a baccalaureate degree are normally regarded as qualified for graduate work. In general, experience indicates rather marked correlation between a student's standing relative to his

undergraduate classmates and his subsequent performance in graduate work. A very large percentage of the qualified engineering graduate students will have been top-quarter undergraduates in their field, though this rough criterion will vary somewhat with the rigor of the school and with individual student development. The majority of good doctoral prospects will lie within a much narrower fraction, perhaps the top tenth or less, but those students who make top grades by rote learning in an undergraduate program may still be poor prospects as graduate students. *The attitude that most students deserve a chance at graduate study is inimical to the intellectual objectives to be achieved and may be damaging in its effect upon those who are qualified for graduate study as well as those who are not.*

Selection of graduate students is a relatively straightforward process for a faculty having high intellectual standards and the courage of conviction regarding these standards. Good students can be selected, however, only after they apply for graduate study. In order to encourage the best students toward graduate work, the great need is to provide the undergraduate student, preferably at the junior level, with adequate information about graduate opportunities and requirements and also about the advantages or disadvantages of graduate study as a means of attaining professional stature. Our best qualified undergraduate students repeatedly undergo a skilled, persuasive presentation of the opportunities available to them in immediate employment. They should have an equal opportunity to know and to examine carefully the available alternatives.

Stipends for graduate students should be increased to a level more competitive with advancing engineering salaries and should reflect the fact that present-day graduate students often have dependents. Employers of engineers must understand that they have a very great stake in increasing the number of graduate students, even though they may lose in the number of immediate employees, and even at the cost of competitive graduate or research fellowships that only they can provide.

Administrative and Financial Support—No graduate school can be successful without the full support of the administrative officers. To be able to provide such support, the administration must have full knowledge of the special problems created by the existence of a graduate school. As at the undergraduate level, the administration has the responsibility to build a strong faculty, to encourage the attraction and selection of qualified students, to provide adequate facilities, and to create a favorable intellectual climate.

The job of building a strong graduate faculty composed of men with the necessary attributes and competencies is difficult, never ending, but not impossible. *A competitive salary scale for a graduate faculty is imperative. Creative talent is always in greater demand than supply. In addition, proper facilities must be provided and a favorable environment developed so that men may pursue those activities of research, development, and creative design which mark the life of the graduate school teacher.* Such facilities include laboratories, adequately equipped; the various service facilities; and an adequate library. Facilities for students, including desks and laboratory space, and housing where necessary, must be provided.

Last and perhaps most difficult of all, the administration must itself have the spirit of dedication to the advancement of knowledge without which no graduate school can become really great. Such a spirit is reflected in an ability to recognize:

1. That in evaluating teaching loads account must be taken of the greater time required for preparation of graduate subjects. Graduate courses should be under constant change with new knowledge being fed in as soon as it becomes available.

2. That research, development, and creative design, which demand a major portion of the professor's time, are part and parcel of the graduate teaching job.

3. That the supervision of thesis research is time consuming even though it is also a rewarding educational duty.

4. That the best graduate programs are based upon the strength of particular faculty members rather than upon any fixed curriculum content.

5. That a strong graduate engineering program requires equally strong independent programs in the basic sciences.

To meet the above responsibilities involves an annual cost per student from two to ten times as great as that required to educate an undergraduate. No school of engineering should consider instituting a graduate program unless it is willing and able to provide the additional funds required.

Policies that permit full opportunity for the professional growth of individual faculty members must be such as to meet the special problems that arise in connection with sponsored research projects, consultation for industry and government, and participation in community affairs. These activities in proper balance provide opportunity for continuing development of the faculty.

In the last decade the amount of sponsored research carried on by engineering colleges has grown enormously. Sponsored research programs properly conceived and carried out can be great assets to both graduate and undergraduate schools. They provide a means of professional development for staff members. However, only when tied closely into the graduate school program will they provide opportunity for graduate students to deal with real and challenging problems as a part of their education. A criterion of acceptability for each project is that competent faculty members actively desire to work on it. However, growth in the size of the projects may so consume the time and energies of the staff that their contribution to education diminishes, particularly if the work becomes more routine and less challenging.

The administration is responsible for the establishment and control of such programs, for retaining proper balance between the sponsored research commitment and the other parts of the educational program of the institution, and for taking whatever steps are necessary to insure that services performed on projects provide opportunity for professional growth for the faculty and the graduate students.

General Character of Graduate Program

Though graduate study in engineering may appear to be but an extension of academic preparation for the more scientific phases of engineering practice, it should represent a considerable advance beyond undergraduate study in attitude as well as in subject matter. Undergraduate education, even when developed on sound scientific principles, must be based on simplified concepts if it is to be understood by undergraduates and if it is to serve as an introduction to practical engineering design. The more advanced concepts are, of necessity, intelligible only on a considerably higher mathematical level and yet it is these advanced concepts that form the basis of our most penetrating knowledge of physical phenomena.

Comparison with Undergraduate and Specialized Programs—The creation of new products, industries, structures, and operations will involve not only scientific analysis of a higher order, but also new concepts of synthesis or design. Training in these categories is limited in undergraduate curricula, not only because students must master a minimum amount of knowledge before they are prepared to extend or apply it, but also because individual instruction on this level is too costly in view of the number of students involved.

Furthermore, genius is not well nurtured by the fixed curricula so characteristically prevalent today in undergraduate fields. *Hence, graduate study should be flexible and custom tailored to suit the individual.* This does not involve unrestricted selection of electives, for universities take seriously their responsibilities in awarding graduate degrees and rightly approve only those subjects that contribute substantially to the major and mi

fields. In engineering one of the required studies is almost invariably advanced mathematics, for the graduate student requires additional mathematics to conduct advanced work and to convey his scientific explanations to others. *On the level of the master's degree anything less than a full-year course in mathematics beyond elementary differential equations appears to be inadequate for effective understanding and use of the scientific principles on which advanced work in engineering will almost inevitably be based.* The doctoral level demands at least an additional year of mathematics. As stated previously, few engineering courses are taught in a manner to make significant contributions to the student's knowledge of mathematics, nor is time available for this purpose.

Student Initiative and Responsibility—Initiative and willingness to accept responsibility become most evident when graduate students undertake the research for master's theses, but more especially for the doctoral dissertations. Such labors usually require (1) an intimate knowledge of related scientific and mathematical principles, (2) experience in collecting relevant and discarding irrelevant information from many sources, (3) the imagination and ability to devise a new and logical method of attack, (4) the perseverance to complete the analysis, (5) the planning and performance of experiments to check the analysis, (6) the willingness to digest these results, and (7) the exercise of judgment in drawing valid conclusions. An appropriate thesis offers exceptional opportunity for additional educational experience and development of the student as well as a test of the degree of their achievement.

Importance of Science—A comprehensive knowledge of mathematics *alone* has little practical utility for an engineer unless it is employed to effect an equally profound understanding of those physical, biological, or engineering sciences which are the necessary background for creative design. All engineers must deal with materials, and they need to understand the behavior of materials when subjected to varying service conditions in mechanical, electrical, chemical, or nuclear fields. Recent advances in solid-state physics indicate that knowledge of materials on an atomic and a microscopic level is required for an understanding of macroscopic or phenomenological behavior. Advanced training in science is thus most important for the graduate engineering student. It matters little whether this science is offered in special courses or integrated into others. It must be covered and can appropriately grow into the proportions of a full-fledged minor, or become an integrated portion of the major field.

Nature and Importance of Research—A young engineer who has an interest in research or development will find his progress more rapid in his chosen field if he can avail himself of the opportunity for the training in research which exists in any good university. The importance of this aspect of graduate study hinges on the exhilarating experience of penetrating deeply enough into some unexplored problem to uncover new truths, and to do this in association with one who has already proven himself a master of the field. The inspiration so derived is essential for a beginner in research, for he must not only learn to circumvent failures but gain the confidence to tackle new and difficult problems as they arise in engineering practice.

Graduate Housing

In graduate even more than in undergraduate work there are important intangible benefits of association with other students and faculty provided by congenial group living in university graduate housing. The graduate student, much more than the undergraduate student, works in an atmosphere of independent individual study and needs for his best growth and development continuous interchange of ideas with and stimulation from students of equivalent intellectual level. *Perhaps no other experience is so likely to develop the inner desire to be truly literate and alive in fields far removed from one's own*

speciality as is a period of congenial residential association with other graduate students. For married students the housing problem takes on a somewhat different form, but the essential issues remain unchanged. Administrative effort to provide housing should be just as vigorous for graduate as for undergraduate students.

Service Programs for Industry and Government

Though it is generally agreed that graduate study in engineering has become indispensable to prepare men properly so that they may contribute effectively at advanced professional levels, only about one eighth of engineering graduates actually acquire graduate degrees. Industry and government have recognized this paradoxical situation and have attempted to find a partial solution through more extensive fellowship programs and more effective industry-university relationships.

In large metropolitian centers late afternoon and evening programs have been initiated by local graduate schools in order to provide opportunity for part-time graduate study. More recently, where travel conditions appear to be unduly discouraging, off-campus graduate programs have been organized. Both represent a service to engineering education when they are carried on as high-level programs, but they give a false sense of achievement if they are not so conducted.

Part-Time Programs

Engineers who are confronted with difficult engineering problems soon appreciate the need for more extensive understanding of fundamental science and engineering science. Their undergraduate studies seldom permitted the extensive preparation in mathematics and physics required for real mastery of basic principles and their application to advanced engineering design or research.

Most frequently, part-time graduate programs are arranged to permit students to attend graduate classes after normal working hours. This arrangement places a heavy burden upon the graduate student. More important, however, is the requirement of a first-class faculty for these evening courses in order to merit the efforts of both institution and student. It is entirely inadmissible to entrust such graduate classes to untried teachers or to men without adequate educational experience. A strong background of practical experience is not sufficient justification for employing an individual as a graduate teacher either on a full-time or part-time basis. Since his appointment as a part-time teacher precludes close contact with other teachers in an academic atmosphere, previous teaching and research experience are essential.

If the course offerings are highly specialized so as to furnish graduate background in narrow fields, outside experts might serve adequately or after some experience even in a distinguished manner as teachers. *However, if the course offerings tend to crystallize into a degree program, members of the full-time faculty must be available to teach at least the majority of the graduate courses.* It is particularly important for degree programs to operate with admission criteria identical with those practiced in the full-time graduate school and to maintain the same standards of performance. Injudicious mixing of auditors or poorly qualified students with candidates for graduate credit is strong evidence that the standards of the program are not at a master's degree level.

The full-time graduate student in a strong engineering school obviously has the advantage of informal association with outstanding faculty members. The evening student may have partial compensation through professional associations in his work. He is usually more mature, but in carrying two jobs he is commonly overworked. As a minimum standard he must have the opportunity, at least in the basic courses, to study under the leading faculty members in his field in order to receive adequate educational stimulation.

It is unnecessary to reiterate what has been emphasized elsewhere many times; the value of a degree is determined by the quality of the faculty that administers it. *A program of appropriate courses alone does not establish a strong graduate school; it must be supplemented by supervised advanced design or research conducted as a continuing program by a distinguished graduate faculty.*

Critical understanding of the basic principles is most impressively demonstrated in a graduate thesis or in equivalent projects of major significance. Without such a creative contribution, whether it be creative design, original development, or research, the graduate degree has deteriorated to a certificate of limited scholastic attainment.

Although doctoral dissertations are now restricted generally to work performed in residence, nevertheless a considerable number of such theses have been completed *in absentia*. There is a widely held conviction within established graduate schools that the major doctoral degree should be awarded only for graduate work in residence that meets high academic standards.

Off-Campus Programs

All that has been said about possible shortcomings of indiscriminate part-time graduate course offerings is even more true of off-campus graduate programs. They are usually organized to meet the educational needs of a particular industry, group of industries, or a governmental research laboratory located an appreciable distance away from the nearest graduate engineering school. Often in their first conception they are not programs leading to degrees.

Unfortunately, more and more the demand has arisen to convert these off-campus programs into advanced-degree programs, in some cases allowing substitution of course work for the graduate thesis. *Real danger to the whole concept of graduate study can come from easy compromise both with respect to the quality of the faculty teaching such programs as well as to the facilities available and the quality of students admitted.* The feeling of obligation can be overpowering, yet the undertaking of responsibilities with inadequate faculty, library, and other facilities can lead only to grave criticism by the professional community and even by the students themselves. The near impossibility of maintaining the high standards expected of resident study without the extensive facilities on the campus has often been overlooked.

One necessary requirement must be the complete educational control of each program by the institution organizing it. Without prior experience in resident graduate study programs a faculty has more difficulty in appraising off-campus activities and should not undertake them.

The Committee feels that many off-campus graduate programs that have been in operation should not qualify for academic degree credit. The Committee also does not believe that any Master's or Ph.D. degree should be given on the basis of an appreciable amount of credit earned in off-campus work. It is possible that certificates or professional degrees may form appropriate acknowledgements of such achievement.

Conclusion

The Committee has been concerned with what it believes to be reasonable, attainable objectives, rather than with Utopian goals on the one hand or minimum standards for accreditation of undergraduate curricula on the other. Nevertheless, responses to the Preliminary and Interim Reports evidenced a wide desire to raise hitherto-accepted minimum standards, and it is anticipated that this Report will assist the Engineers' Council for Professional Development (ECPD) in attaining such a goal.

In closing this Report the Committee wishes to re-emphasize that it believes the spirit of its recommendation in advocating scientifically oriented undergraduate curricula must receive more attention than mere observation of proposed fractions

of time devoted to particular areas. It gave a great deal of thought to the possibility of prescribing the level of attainment in each of the areas of importance in engineering education, but it was unable, except possibly in mathematics, to make a quantitative specification which would take into account the inherently dynamic nature of the basic sciences and more especially that of the enginering sciences. College faculties must perform this work year by year.

The task initially undertaken by this Committee is not finished nor can it ever be finished. The problem of the Evaluation of Engineering Education should always be in the consciousness of the members of faculties of engineering colleges. Each teacher must consider this task a vital personal one and approach it with intellectual vigor and full consideration for the needs of an expanding economy, requiring engineers with vision, creative ability, and sound training of truly fundamental nature. Since these desired qualities cannot be achieved for all students in an identical manner, elective study is recommended. *The choice of electives at the undergraduate level contributes to the development of a stronger humanistic and social background for some engineers and a stronger scientific background for others with a resultant overall strengthening of the profession of engineering.*

The interest and effort shown by the Institutional Committees make this Committee optimistic that improvement will be sought, and it therefore recommends the implementation of its Report at the local level. Improvement of engineering education is the responsibility of every teacher of engineering students.

Appendix A

Historical Background of Previous Evaluation Studies

Since the organization of the Society for the Promotion of Engineering Education in 1893 there have been many studies of engineering curricula which reviewed content of the several programs and gave a distribution of time to the major divisions of the work. Out of the study begun as the Mann Report, published as Carnegie Bulletin No. 11, came the Wickenden Report of 1923–29. It was followed by "Aims and Scope of Engineering Curricula" in 1940 and "Engineering Education After the War" in 1944, produced under the chairmanship of H. P. Hammond. D. C. Jackson's "Present Status and Trends of Engineering Education in the United States" was published in 1939, and its study of curricula may be considered as a supplement to the Wickenden Report.

Since the Wickenden Report is so basic and fundamental it may be desirable to quote a few sentences:

"The multiplication of trunk and branch curricula based on technical specialization has gone fully as far as can be justified. Further differentiation in courses for undergraduates is much more likely to proceed on functional lines."

"The most serious deficiency in engineering education is not so much in matter taught or matter omitted in college as in allowing the orderly process of education to stop, where it so often does, at graduation."

The 1940 and 1944 Reports, referred to above, emphasized the division of each curriculum into two major areas, titled the scientific-technological stem and the humanistic-social stem. These two studies renewed interest in the "general academic subjects" listed in The Wickenden Report. The wording used in describing the humanistic social stem is practically identical in both Reports and the time suggested for this area was twenty per cent of the total. This cultural program was to be an integrated sequence running through four years. During the last decade much thought and much study have been given to this phase of engineering education.

Both Hammond Reports recommended the four-year undergraduate program as the desirable norm. However, it was recognized that engineering graduates enter into many kinds of activity and that there should be comparable differentiation in

their educational programs. In summarizing the 1944 Report, Dean H. P. Hammond outlined the needed preparation for widely varying engineering activities as follows:

"In order to provide for the satisfaction of the needs incident to these trends, the (1944) Committee suggests, for consideration, a plan of curricula differentiation in the fourth year, through which three options would be offered within each major professional curriculum: (1) Continuation of the present type of four-year program essentially as a terminal curriculum but with modifications advocated by the Committee, for a majority of students. (2) An alternative fourth year emphasizing subjects dealing with the management of construction and production enterprises. (3) A fourth year intended to prepare for additional years of advanced study by strengthening the student's command and extending his knowledge of basic sciences and mathematics, and by introducing him to the methods of advanced study. This fourth year, and the year or years of graduate study to follow, would be planned as a unit rather than as two stages marked by the usual differences of undergraduate and postgraduate programs."

In 1950–52 the Society conducted a comprehensive study on methods of improving engineering instruction. This study resulted in publication of an ASEE Monograph entitled "Improvement of Engineering Teaching." This report dealt at considerable length with the problem of "how to prepare students to meet new situations with skill, resourcefulness, and leadership." It also treated the collateral problems of "how to instill in the student the desire to continue to learn after graduation and how to provide a cultural foundation which will encourage him to contribute to his local community and to civic groups as a mature, thinking human individual."

The principles of learning outlined in this report stressed "the importance of effective participation on the part of the learner; his motivation through the formulation of a goal; the clear definition of task assignments (preferably defined by the student himself); the evaluation of his progress; and his repeated practice in application." This project was participated in by committees in over 100 engineering colleges of the country.

In 1945 the Division of Graduate Studies of ASEE prepared a "Manual of Graduate Study in Engineering." This was completely rewritten in 1952, and reissued in monograph form. This Manual deals with the following: (1) the objectives of graduate study, (2) organization, (3) transitional studies, (4) developing a graduate faculty, (5) admission requirements, (6) degree requirements, (7) major, minor, and research, (8) the thesis, (9) language requirements, (10) mathematics, (11) examinations, (12) undergraduate courses, (13) non-technical studies, (14) evening classes, (15) cooperative programs, (16) sponsored research, (17) industry institutes, (18) foreign students, (19) student guidance, and (20) teaching loads.

The Committee on Evaluation of Engineering Education gladly acknowledges its debt to the many preceding committees that have reported on their studies of engineering education. Its work bears a close relationship to that of the committees that prepared the "Manual of Graduate Study in Engineering" and the report on "Improvement of Teaching in Engineering" because of the partial overlapping of the committee membership.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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Report of the Committee on Ethics*

Engineers are often accused of being material minded. People say that we decline to take an interest in anything except steel, concrete, water, oil or steam, and that most of us not only refuse to pay any attention to intangibles and abstractions, but that we are mentally unable to comprehend them.

This accusation is not warranted if the concern of engineers and engineering educators about ethics means anything. Indeed, engineers' interest in ethics seems to be quite spontaneous, so that the Committee on Ethics can claim little credit for it. The concern of engineers is altogether gratifying because to create interest in ethics, and to maintain such interest, has been the principal function of the Committee from the day, in 1952, when President Woolrich created it.

One evidence of interest is the volume of correspondence. The Committee on Ethics, like any committee of the Society, is ambitious; it has designs, projects, aspirations. The members are eager to get on with their principal business. However, they have been so tied up by a mass of correspondence that there has been little time to do anything else.

Of course, if maintaining interest in ethics is the Committee's primary aim, the correspondence is all to the good. In any case, correspondence is one means whereby the Committee can serve the members of the Society, as a committee should.

It would be inappropriate, and doubtless impossible, to recite in detail a sequence of evidence to prove that engineers are interested in ethics, and that intangibles and abstractions are not always beyond their comprehension. One example will suffice. An article entitled "Employers, Ethics and Novice Engineers" appeared in the January, 1955, issue of the JOURNAL OF ENGINEERING EDUCATION. The article was reproduced, slightly abridged, in both *Civil Engineering* and *Electrical Engineering*, published respectively by the American Society of Civil Engineers and the American Institute of Electrical Engineers. When these journals were issued, engineers in great number wrote in to express a variety of viewpoints from widely scattered areas, including Australia. The editor of *Civil Engineering* wrote about a survey which disclosed that this article surpassed all other items in that issue in reader interest. The article was reproduced in full or abstracted in many local and special technical and engineering periodicals.

Persons and agencies, both within and without ASEE, have repeatedly urged the Committee on Ethics to ascertain what engineering faculties are actually doing about imparting ethical ideals to their students. During the present school year the Committee passed the question on to the deans of the colleges and schools of engineering. The Committee inquired of the deans in the 149 institutional members of ASEE. 87 replied. That is nearly 60%, and without getting statistical, it surely means that the deans are concerned about ethics.

Not a few of the deans have misgivings about the formal teaching of ethics: "We accomplish more by the good example of our faculties, and an atmosphere of honor and integrity in the college of engineering and on the campus." Ethical deportment of the faculty and a favorable environment on the campus are both obviously essential, regardless of whether or not courses in ethics are offered.

* Presented for the committee by W. W. Burton, Minnesota Mining and Manufacturing Co., June 20, 1955, at the annual meeting of ASEE, Penn State University.

Tabulated data are tiresome but the following tell something of what the colleges are doing:

In a large number of the institutions the dean or other official gives lectures or holds conferences on general or engineering ethics, or both. These institutions constitute 45% of those who replied. The content of the lectures or conferences is apparently well organized. But the operation of the program seems rather casual in some cases. It is not always clear if attending the lectures is a required exercise or whether they are merely available to all students. Some of the faculties probably feel that the real value of the lectures lies not so much in their subject matter but rather in that they help to maintain an atmosphere of honor and integrity in the school.

In some of the institutions it is the policy to depend entirely upon an environment or a spirit of honor on the campus, and on the inspiration and superior deportment of the faculty. These institutions are 23% of those who replied.

In a smaller number of institutions, responsibility for instruction in ethics is assumed by degree departments of civil engineering, mechanical engineering and the like. These institutions comprise 16% of those who replied. Instruction is offered by one or the other member of such departments of instruction, who is enthusiastic and informed in general or engineering ethics, or in both. The lectures are regularly scheduled but usually it was not explained whether students do or don't have to attend. In some of these institutions, courses in ethics are offered by all departments, but more frequently only in one or several. Even when ethics instruction is offered in all departments, the project still remains a departmental undertaking and not a project of the college or school as such.

In a very few institutions all students must complete courses in ethics, and in two or three colleges, courses in both ethics and religion are a degree requirement. Those faculties which require courses in religion contend that religious instruction is excellent for teaching students the difference between right and wrong. Institutions which offer required courses in ethics, in religion or in both constitute 9% of the total which replied.

Finally, there are six institutions whose deans confessed that they do nothing whatever about instruction in ethics. This does not mean that they are not concerned. It doubtless means rather that they are perplexed, and don't know how to proceed. The problems of education in ethics are difficult, and solutions are more so. In fact, one dean has taken the pains to prepare a thought-provoking statement on the professional status of engineers, and with appropriate reference to engineering ethics. He wrote the monograph to clarify his own thinking before he approaches the matter of instruction in ethics.

Members of the Committee have been diligent in their principal business, for the time being, of promoting interest in ethics. Collectively, the members of the Committee have delivered addresses on ethics, or on the subject of professional status with reference to ethics, as follows: Before two meetings of sections of ASEE, before one annual meeting of a national society, before one regional meeting of a Founder Society, before three meetings of state engineering societies, before two meetings of city engineering societies, and before three student branches of national engineering societies. One member of the Committee has even become so distinguished an authority on ethics that he has been invited to discuss the subject before a church group. Members of the Committee have contributed to engineering and technical journals.

Early in the year the Executive Committee of ASEE proposed to the Committee that copies of the (our) Canons of Ethics of ECPD be issued to the deans of the colleges of engineering, and that they be framed and placed in central locations where a majority of the engineering students frequently gather or pass.

The officers of the National Society of

Professional Engineers generously offered to provide and mail the copies, after the Committee had corresponded with the deans and explained what the Executive Committee had in mind. Many of the deans wrote for additional copies. Others reported that they had long since framed and displayed the Canons. In general, the reaction was favorable.

However, the chairman of the Committee has in his possession a photograph which was taken and sent to him by one of the members of the Committee who regularly visits a number of the colleges of engineering. The photograph shows the official bulletin board in one of our well known institutions. Hanging precariously by one thumb tack, among miscellaneous dilapidated documents, is a badly rumpled copy of the Canons. The Committee suspects that the Canons did not get even as far as the bulletin board in one or the other college of engineering.

The Committee on Ethics wishes to express to the officers, the Council and to members of the Society their deep gratitude for consistent encouragement and assistance, and for making the Committee feel, in many ways, that the Society considers its work to be worth while.

THE COMMITTEE ON ETHICS

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ANNUAL MEETING

June 25-29, 1956

Iowa State College

Ames, Iowa

What Is the Responsibility of the University in Contacting the High Schools?*

By J. F. DOWNIE SMITH

Dean and Director of Engineering, Iowa State College

Introduction

The subject of my talk is to be "What is the Responsibility of the University in Contacting the High Schools?" For obvious reasons I am limiting my discussion to the Responsibility of the Engineering Colleges.

Before outlining what I consider these responsibilities, it seems appropriate to outline some of the problems which jointly confront both Colleges and High Schools, and then discuss what the Colleges may do. We must understand the situation before we make recommendations.

The Primary Problem

For a long time, engineering colleges and high schools have been rapidly separating in viewpoint, and there has been an increasing tendency on the part of engineering educators to criticize the activities in high school, sometimes quite bitterly. The most vociferous critics of high school training, however, have perhaps been outside the field of engineering. Some claim that the high school graduate is not properly prepared to undertake study at the college level. His English is poor, and he has not been trained to think.

In a nutshell our primary problem is this: Engineering is becoming highly technical, and in the development of this science there has been increasing dependency upon the use of mathematics, physics, and chemistry. Thus, engineers would like those subjects, and English, taught well in the high schools and they have raised the question whether the high schools are doing this. Many of the high schools are, but these high schools are ordinarily located in the large centers of population—and by large, you understand I am speaking of Iowa, where any town larger than 15,000 is a fair size. But many of the schools are not teaching even enough mathematics to satisfy the engineering educator. The reasons behind this are equally obvious. We, as engineering educators, realize the difficulties of getting budgets to teach all the various courses which our faculty would like to have taught, and at times I am appalled at the number of courses taught in college. For example, on the campus of our college, which is perhaps a typical medium-size land-grant college, with only five divisions, we teach more than 2000 separate courses. The elimination of many of them is not easy, even though some classes have few students.

The high school principal and superintendent are confronted with a different problem. Let me illustrate that again by a reference to Iowa. Of the 836 high schools in the State, 486 have fewer than 50 pupils. In addition, a large part of the rest of the schools in the state have fewer than 100 pupils total, or about 12 male seniors; and thus, from perhaps 80% of the schools we would normally expect fewer than one student coming to engineering college. Under the circumstances the school officials will pay little attention to what the engineering college wants. This is important if we are considering the selection and guidance of high school students. The high school principal says

* Presented at the Annual Meeting of ASEE, Penn State University, June 23, 1955.

that about one-third of his graduating students, on the average, would go to college. The other two-thirds would consider high school their terminal program, and the schools have to consider their average student in preference to those going to college. There might be a serious question, from the standpoint of civilization, whether this should be true. Perhaps the brilliant student should be given much more consideration in high school than he is now given, but from the economic standpoint it would not be easy. In certain of the other countries of the world the brilliant student is given preferred treatment.

Where Do Our Students Come From?

A few years ago one of our staff members made a study of the entering freshmen at Iowa State College, and obtained the following data.

In the year 1951, 38% of the freshmen from Iowa entering Iowa State College in engineering came from high schools with 40 or less in the graduating class. Sixty per cent came from high schools with less than 80 in the graduating class. About 61% came from communities with populations of less than 10,000. Again in 1951, 193 communities and 216 different schools were represented by the 419 Iowa students taking freshman engineering in Iowa State College. *One hundred and thirty-four Iowa high schools were represented by only one student.*

The Changing Emphasis in High School Training

Why has there been any change in viewpoint in the high schools? The situation becomes quite clear when we read what Dael Wolfle has to say.*

Educational Improvements

"In 1870 two-thirds of all high school graduates later earned college degrees. The role of the high school was then clear and unambiguous: it prepared students for college. That is still an important function, but now a minority one. With the great expansion of secondary education high schools have taken on increasingly diversified responsibilities. Not only do they prepare students for college, they prepare them for jobs in offices, for work as skilled tradesmen, for citizenship in an increasingly complex society, and for a variety of other objectives. The declining importance of college preparation is indicated by the decline from 1870 when two-thirds of all high school graduates became college graduates to 1940 when only one-sixth became college graduates. The percentage has increased slightly since 1940, but the college-bound student is still in the minority in most high schools.

"High schools face the double problem of preparing one-third of their graduates for college entrance and two-thirds for the career and citizenship responsibilities of noncollege adults. In this situation different educational theorists have emphasized different values. The college preparatory curriculum has been defended by some while others have attacked it as an anachronistic heritage of an earlier day. 'Life adjustment education' has been hailed as the highest goal of the high school, and condemned as dangerous anti-intellectualism. All these attitudes are one-sided; the choice is not between serving the needs of one group or the other. Both must be served. The two-thirds not headed for college deserve the best the high schools can give them. The one-third who do go to college are also an important group, deserving the best possible preparation for the higher education which they will receive later."

The Teaching of Science Subjects

The effect of this changing emphasis is reflected in matters of interest to us, particularly in the teaching of science subjects.

Members of the Iowa Academy of Science have been making studies of science teaching in high schools of the State, and

* "America's Resources of Specialized Talent," Dael Wolfle. Harper, pp. 252–253.

results of these studies seem to indicate that there is room for improvement. In this study it was found that 79% of the teachers taught some other subject in addition to science, and that some taught as many as four other fields; 48% were teaching in at least three fields, including science, and it is possible that the main interests of those teachers was not in science, but was in other areas.

In 1949, in the last four years of high school about 25% of the students were taking general science; 0.1% earth science; 19% biology; 1.2% physiology; 3.6% chemistry; and 8.4% physics.

(Nationally in 1949, the percentage of high school students taking algebra was 26.8; general science 20.8; biology 18.4; general mathematics 13.1; geometry 12.8; chemistry 78.6; trigonometry 2.0; physics 5.4; physiology 1.0.)

The decrease in enrollment in high school physics, according to the Iowa study, is disconcerting, because there is nothing to indicate that another science is replacing it, as has been the case with physiology and earth science. The effect of size of school is clear. In the high schools in Iowa, 1951–1954, one semester or more of chemistry was offered in 39% of the schools. The percentage increased from zero in high schools with twenty-five pupils to more than 90% in high schools with two hundred or more students.

While high school enrollments are increasing, the proportion of college graduates who are qualified to teach mathematics and science in high school is decreasing. The National Science Foundation indicates * that between 1950 and 1954 the total number of college graduates meeting certification requirements to teach in high school dropped 42% and the number qualified to teach mathematics and science dropped 51% and 56% respectively. Of this number, many find employment in other fields. A recent study showed that only 40% of the 1953 college graduates qualified to teach science and mathematics *were* teaching in November of that year.

The same study indicated that of the high school students who graduated in the upper quarter of their classes, about 40% failed to continue formal education and another 13% dropped out before completing college.

The Teaching of Other Subjects

According to John Francis Latimer, George Washington University, "the number of secondary students studying languages has dropped from three out of four in 1900 to one out of four today. French has dropped from 8% to 5%; German, from 14% to 1%; and Latin, from 50% to 7%. In 1900, at least four out of five students took mathematics; today fewer than half the students do, and of these 13% are taking general mathematics. The biggest slump is in algebra, which is down from 56% to 20%. Physics has also suffered. In 1900, four out of every twenty students took physics. Today it is one of twenty.

"In place of these traditional courses there have been substituted group action subjects, which require little individual effort, and certainly not much demand on a serious intellect."

There have been serious criticisms of the quality of instruction in such fields as English.*

On the other hand, according to Gwilem A. Price, "at the turn of the century, almost 11% of our population could not read or write. The average person did not finish grade school. Today illiteracy has virtually disappeared, and approximately 50% of our boys and girls graduate from high school. More youngsters now get college degrees than finished high school in 1900."

The professional educators do not agree with some of the criticisms. They will all admit that the *number* of subjects taught in the physical sciences has been reduced, but insist that, of those which are actually

* 4th Annual Report, for the year ending June 30, 1954.

* *Time*, January 24, 1955.

taught, the students are as well prepared as they were twenty years ago.

According to Dr. John W. Studebaker,** formerly United States Commissioner of Education, public schools are doing a bigger and better job of teaching the fundamentals of learning today than they did in the "good old days." His conclusion is based upon actual cases in reading, writing, spelling and arithmetic.

In talking this over with representatives from the Teacher's Colleges I find they are quite strong in the belief that the students are better prepared now, and are sure they can back this up with statistics. It is always difficult to give a test which really means the same to one group as it means to another group twenty years later, since the viewpoint of the entire civilization may have changed. Nevertheless, tests which were given to certain students twenty years ago were given to the same grade twenty years later and the newer students got better grades than the previous students.

Part of the criticism of the schools is really not justified. Some of the blame belongs in the home. There has been an increasing failure of the parents to develop character building and training of the mind. This has been delegated in increasing amounts to the school.

Financial Problems

All of the disciplines which we in engineering would consider desirable are not being taught in high school. To some extent, the problem is financial. In many of the states, certainly in the Midwest, the schools are small and the cost of instruction high. For example, in Iowa the present pupil cost in the various districts varies from $200 to $1300. The assessed valuations vary from $1000 to $100,000 per pupil. There are 4400 school districts in the state, but 1200 of them maintain no schools.

There has been a strong move toward reorganization and consolidation, but you realize that local pride—sometimes pride in a basketball team—occasionally prohibits consolidation of schools. Nevertheless, considerable progress has been made.

In many of the rural communities the cost of operating schools is prohibitively high, and the relative cost of training in school and college is sometimes not clearly understood. For example, in Iowa, the state and local expenditures for education are substantially above the levels in most other states in relation to income; yet, seven-eighths of the cost are for elementary and secondary schools, caused partly by the low population density in non-urban areas. The reorganization of the school system is being considered, to see if more efficient operation might be obtained. This is a very important item to the colleges, as well as to the high schools, since, in publicly supported institutions, the high school and the college are *competing for the same money.* There is a limit beyond which taxes cannot be raised without great difficulty. Thus it is mandatory, for the good of the colleges as well as the high schools, that the two get together to improve efficiency in both. There are several obvious ways in which this can be done, but they would vary from state to state.

The time has come when we must encourage and work with the high schools, and not keep lambasting them for the poor job they are doing.

What Should We Do?

I have discussed at some length a few of the problems confronting the high school administrator, for they all have a bearing on our own responsibilities, and affect our judgment in selection and guidance. In order to remedy part of our difficulties we must interest intelligent people becoming teachers in high school and grade school. This cannot be done in adequate numbers under the present circumstances. The salaries paid high school and grade school teachers are woe-

** "101 Questions About Public Education." Nat'l Conference of Parents and Teachers.

fully inadequate, but there is much more to it than that. The prestige of the profession is low. In many countries the high school teacher is looked upon as one of the outstanding professional men in the community. Outside of the athletic staffs I doubt if that is the case in this country. There has been a growing awakening of the public towards this problem, and steps are being taken in many communities towards its solution. This must be done. Because of the financial imposition, many of the talented people who might be interested in teaching in high school have not been attracted to it, and some of those who were at first attracted have since left that profession. To a large extent, the difficulty is traceable to the lack of inducement of people who have the required qualifications to go into high school. People with those qualifications are also in demand by industry, and industry can afford to pay better than high schools.

Unless we can encourage the proper people to teach in high schools, we shall not get from those schools adequately trained students.

High schools are lacking in competent teachers in the sciences and mathematics. They also have certain restrictions about who can teach in high schools, and some of these restrictions involve certifications obtained from teacher training colleges.

It is becoming increasingly common in industry, and in some colleges, to require the retirement of people from administrative duties and, in some cases, from all duties, at the age of 65 or thereabouts. Is it not possible that some of those men could be of distinct help in improving the teaching situation in high school, even though they do not have teaching certificates? Certain teachers in the teacher's colleges who are listed as specialists are not required to have teachers' certificates. I believe this topic could be profitably explored in more detail. Men who are now hired to teach are very often primarily hired because of their athletic ability, and then, in order to fill their schedule, they are expected to teach something—which may be mathematics or physics.

There is also a growing number of men retiring from active military duty who are looking for things to do.

The Relative Responsibilities of College and High School

What are the responsibilities of the College towards the High School? Rather than have the colleges tell the high school what the high school should do, or vice versa, I think we ought to lay down certain basic principles. The Illinois Department of Public Instruction and the University of Illinois College of Education have considered this matter and have reached the following conclusions:

"Certain principles were agreed upon regarding the respective responsibilities of the secondary school and the college:

"1. The American public high school has the responsibility to develop and administer an educational program which will provide for the education of all youth. . . .

"2. With limited resources, the high school's first responsibility is to provide education of general value to all its students. . . .

"3. The colleges and universities bear the responsibility of continuing the general education of high school graduates and of providing for various specialized needs. . . .

"4. The high school, not the college or university, has the responsibility of specifying the content of the high school curriculum. . . .

"5. The high school has the responsibility of providing colleges and universities with information about its students. . . .

"In the light of these principles, it is recommended that the colleges adopt admission policies which do not specify the courses the students are to take in high school, but specify the kinds of competence to be required of entering students. . . .

"For specialized curricula, certain specified competencies on the part of high school graduates may be required, such as competence in mathematics for engineering. For such cases, the Committee recommends the adoption of the following paragraph:

"Secondary schools are urged to provide means for high school students to acquire, prior to graduation, the competencies demanded for successful work in specialized programs in institutions of higher learning, such competencies to be determined on the basis of standardized tests rather than on the basis of passing specified courses.

"The purpose of the last recommendation is to urge provision in high schools for specialized work really basic to college specialization. The Committee recognizes that smaller high schools will not always be able to provide a sufficient variety of specialized courses to meet the needs for special programs of all its graduates. In such cases, the colleges are urged to make provisions for the basic specialized work with as little handicap to the student as possible."

If these recommendations are to be accepted, the principals, superintendents, and vocational guidance counselors in the high schools must be given advice. Much has already been given.

The Engineers' Council for Professional Development has prepared a pamphlet, "After High School—What?" This has been sent to each high school in the country and it should aid considerably in this guidance problem. They have also prepared a second pamphlet called "Engineering—A Creative Profession." Both are excellent.

The various professions and occupations need more mathematics than they are now getting. Many do not realize where mathematics fits into everyday life. The General Electric Company has produced several pamphlets on such matters as the use of English, mathematics, and so on, which they have distributed to the high schools. They should be helpful. Some professions such as psychology, could benefit from the use of more mathematics than are now used.

The solution to these various problems should be regional and not country-wide. Trying to impose on one section of the country what would be perfectly normal for another could lead to difficulties of a rather serious nature.

The Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science is attacking this problem in a vigorous manner. Industry is also doing its share. For example, the duPont Company in the year 1955–56 will spend more than $800,000 in aid to education. Of this amount, $291,000 has been set aside for the improvement of the teaching of science and mathematics, and $75,000 of this latter amount will be used for summer and winter fellowships for high school teachers who would like to continue for the master's degree.

The Engineers Joint Council, the National Association of Manufacturers, and many individual corporations have all contributed handsomely to this guidance program.

Many of these organizations have distributed to the high schools brochures showing the importance of various scientific subjects to people in all branches of life, including those who expect to go on to college and into engineering. The reception to these brochures in high school has been excellent. Many vocational guidance personnel are now realizing, perhaps for the first time, the general importance of subjects like mathematics.

In addition, various industries have been accepting high school teachers for summer work. This serves the triple purpose of giving the teacher additional income, of giving him a knowledge of what industry is doing and what it needs in those who go to that industry, and also serves as good public relations for the industry. There are other incidental benefits, but these seem to be the principal

ones. Much more of this could be done with profit.

The university or college officials should encourage such activities. They are part of a proper guidance program.

Some colleges have been quite stiff in their dealings with high schools, and have said, in a nutshell, "the high schools will teach these subjects or else we will not admit their graduates to college." In other colleges this viewpoint has been materially changed to permit all high school graduates to enter, with the opportunity to take, in college, for non-college credit, those subjects which are necessary before a student could become regular in college. In general, these deficiencies are of a minor nature and merely extend the period of training in college perhaps one quarter or one semester. There is, naturally, a difference in viewpoint on such matters between State supported and private universities.

Students are very often not getting proper guidance in high school. The right kind of student is frequently not being encouraged to continue to college. Many students are advised not to take engineering in college because of the high failure rate of such students. It is not generally realized that the failure rate in engineering is no higher, as a percentage, than most of the other major professional schools. Perhaps some of the reason for this is traceable to the fact that engineering, on the whole, attracts a better than average intellect.

For some students, the first one or two years of college are frustrating. Such students may have come from high schools or preparatory schools which have a very high standard. When they get to college, some of their first year in college is repetitive. It is clear that if the schools of that type and the colleges could get together, there could be the elimination of part of this duplication—and this is what a few colleges have decided to do. The able student should be expected to travel more rapidly through the college program and perhaps start at a higher level than has been customary in the past. This is common in Europe.

One college with a very interesting approach is the University of Illinois. They have prepared a brochure in consultation with the Department of Mathematics, College of Education, and College of Engineering, which they have been using with the high schools. The University of Illinois is now requiring four units of mathematics as entrance to its Engineering College for full acceptance. The brochure, however, spells out specifically the topics which the students should have in their study of mathematics in high school. This, to me, has a great deal of merit and, in my opinion, should be welcomed by the high schools, although they may consider that this is given from the biased viewpoint of the engineer. It has, nevertheless, the approval of the College of Education. I should like to point out, however, that the University of Illinois gets a very large percentage of its students from metropolitan areas and this is a simpler matter to handle than would be the case in many of the western or southern states.

Dr. Carroll V. Newsom, Associate Commissioner for Higher Education at the New York State University, has proposed a study of High School-College Articulation in Mathematics which is being considered by the ASEE Committee on Secondary Schools.

Career Days

In many states it is customary for the high schools to have Career Day programs. During those programs they expect to have representatives from each of the professions, trades, and other occupations, talk with the students and outline the opportunities in the field and what would be expected of a graduaate. During a year, the engineering staff of Iowa State College participates in a great many of these career days. Each career day is sponsored by one high school at least. However, in general, many high school students from different communities at-

tend each meeting. For example, in the year 1954–55, 446 cities were contacted and 2340 high school students attended the engineering sessions. This is a tremendous increase in interest in a very few years. In one case, Ames High School, the career day program only involved Ames High Students; whereas in another career day program only 32 miles away, 29 cities were represented in that one program. Altogether, there were 46 separate career days attended by a representative from the Engineering Division.

During the career days, the representative from engineering talks about engineering in general, about no particular college, but talks briefly about each of the various branches of engineering, regardless of whether they are taught at his own college. He describes the opportunities and so on. But in the period allotted to him, clearly there are many items which can't be covered, and it has been our practice to pass out cards to the students who attend, so that they would give us some information we would like, but we also give them the opportunity, when they return the cards, to ask about particular programs or to ask specific questions. For each of the departments at our college we have a printed statement of that particular branch of engineering, showing what the graduate might expect to do, where he might live, what his opportunities would be, and so on. We also describe in detail what is expected in each of the fields. This sort of activity is appreciated greatly by the high schools. The vocational guidance men or women in high schools are very often not fully aware of the importance of some branches of engineering; and these are occasionally emphasized at career days, often getting encouraging requests for information.

There has been a tendency to consider for entry into engineering colleges only those students who have high grades in high school. I think this could be a mistake, unless this particular fact is combined with other factors. Low grades in school may be traceable to many things. They may indicate, for example, that the student is not interested in what is taught in high school. There are many students who do far better in college than they did in high school, because for the first time there is a challenge to their mentality. Such students very often get better as the years go along.

In some schools, as in some colleges, there are poor teachers, and they tend to stifle the interest of the student. There is also an occasional lack of motivation of the student who does not quite know what he wants. He may mature later and become excellent. In addition, high scholastic scores are not ncessarily indicative of high ability. Thus, we should be careful about saying to a prospective engineering student, "You are not qualified for engineering."

Television and Radio

Some of the colleges in this country either have television or radio stations of their own or have access to such stations and have some knowledge of their operation. High schools frequently have television receivers, and most have, or can get, radio receivers.

We have taken advantage of this situation on our campus to schedule a 15 minute radio interview each week during school days at a definite predetermined time. Each interview gives vocational guidance in the various fields which ordinarily interest high school students. Some of these activities require collegiate training and others do not. But at least we give accurate information to a wide section of the high school student body, and it is appreciated by them. The high schools set aside the period to listen to the program.

On our television station we also put on programs of an educational type showing what engineers, chemists, and physicists do. This is done at night, and has a large audience.

Some time ago at our college, we gave a short course during the summer for

teachers of engineering drawing. I believe this was well received by the vocational teachers in the various technical high schools.

High school administrators must, in the future, demand more intellectual stimulation of the students and more serious work from them. Few high school students in the first two or three years of high school have much, if any, homework to do. This is quite a contrast with what is in evidence in other countries of the world.

Pre-College Examinations

As the flood of students wanting to study engineering begins to appear on the campus, administrators will be confronted with the need for additional staff and facilities. They will not easily be obtained, if my reading of the mood of legislators is correct. Thus there will probably have to be a curtailment in student numbers. I hope this will not be on a first come first served basis, but will be based on quality. This may mean the examination of students sometime during their senior year in high school. This will be a new venture for some colleges, but, in my opinion, will shortly be necessary.

The ASEE Committee on Evaluation of Engineering Education has considered this matter, and has stated in its final report:

"In order to encourage high school-college articulation, it is recommended that a study be undertaken by ASEE in cooperation with professional and industrial groups and societies representing mathematics and the pure sciences for the following purposes:

"1. To determine specific techniques for identifying, encouraging, and developing those high school students who have aptitudes for engineering.

"2. To determine methods for developing adequate study habits and a suitable level of performance in reading ability for those students planning to attend college.

"3. To develop specific techniques of reaching high school faculties and administrators in order to enlist their cooperation in a constructive program to improve the quality of high school preparation, particularly in mathematics, physics, chemistry, and English.

"4. To determine, at each university engaged in teacher training and having a college of engineering, ways of providing advanced study as a part of high school teacher education that would make such teachers more proficient instructors in the subjects necessary for admission to engineering.

"5. To develop specific techniques for presenting these problems and their possible solutions to high school administrators, teachers, and the general public."

It would appear then that instead of constantly criticizing the high schools, we might offer to work closely with them to see if we can solve problems of joint interest. The training of an engineer is not something which starts in the freshmen year in college and finishes four or five years later. The training of an engineer begins at birth and is not completed until his death. It is time, then, that we considered the whole training and, as a first step, I should like to emphasize that college administrators get together with high school administrators and try to work out their problems of mutual interest. In such a spirit of relative good will, I think much could be accomplished.

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
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Duke University

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LEE HARRISBERGER
N. C. State College

Getting the YET Message Across

By PETER L. BALISE

Department of Mechanical Engineering, University of Washington

We're Young Engineering Teachers—but what are we supposed to do about it? From the title of this article, the answer apparently is: Get the Message Across—but what message? Why should there be a special idea of Young Engineering Teachers?

Young Engineering Teachers makes no sense if it is just a scheme for having another subdivision of ASEE. But YETs do make sense, and aren't just a subdivision of ASEE. The purpose of the YET idea is simply to help provide an opportunity for younger teachers to take a real part in ASEE and other professional society activities. Such activities are rewarding, sometimes indirectly in dollars, but more important in making worthwhile how we spend eight hours a day or more. Unless a fellow is content merely to shovel out stuff from the text to the student (which might get monotonous after 40 years), he has to keep learning himself. One way to do this is by engaging in research, and another is by reading current literature. Both of these are important, but there is another, very pleasant, way of keeping up to date. That's by getting together with others in professional societies.

Your first thought may be that you're too young and inexperienced to be wanted except to fill another seat in the audience. That just isn't so. They aren't likely to put you up for national society president next year, but any professional organization is looking for the benefits of the eager, inspired, imaginative, enthusiastic, fresh outlook the younger fellows are supposed to have. There are many responsible positions available for younger members, and once you get acquainted by serving on committees, the thing snowballs and you are wanted more and more. One of the chief advantages of professional society activity is getting acquainted, from which you learn what is going on today in engineering and what the actual practical problems are; as well as making it possible to enhance your classes by drawing on visiting speakers and teaching aids you encounter in so-

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."

YET-itudes! Not Platitudes!

ciety activity. Talking with people you meet at meetings can be just as valuable as the papers you hear.

Speaking of papers, probably anyone who's stayed with this one so far doesn't need to be convinced of the opportunities in professional society activity. The question is, how can other YETs be convinced? It isn't going to be done by passing a resolution or printing an exhortation to "get active." A personal contact is necessary, and most of us are not crusaders enough to go around collaring everybody and giving speeches about the advantages of taking an active part in the ASEE or any other professional society.

The purpose of this article is to show how you can have a meeting of the YETs on your campus that will really accomplish something rather than make everybody wish there were fewer meetings he had to attend. And this can be done without bringing in outside talent to amuse and amaze the group. The following suggestions are based on successful experience, not on wishful imagination.

A dinner meeting is best to provide the informal atmosphere conducive to discussion, and is planned as an opportunity for the younger teachers to find out exactly what things are important for successful teaching on the local campus. Who should know this better than the dean and department heads? So they are invited, the dean being asked to give a short, informal talk on the place of professional society activity in your school. Note that this is not a speech title in capital letters; a stirring oration that tells nothing is not the idea, but rather a few remarks from one of the men on campus best qualified to express his opinion.

Of course we hope that someone besides the dean and department heads will come to the dinner. The fact that the boss will be there is an effective inducement to the younger teachers to attend; however, they must be contacted individually. You can invite whomever you want, within reasonable limits, such as all those under 36, which list may be provided by the dean's office. A good plan is to send invitations, individually typed if you can get someone to do the work, asking for a reply by a certain date. Then you take the charge of the campus dining service or restaurant and by well known mathematical technique determine how much each person must pay. You then pass the word that you'll reserve places for those who send you a check.

There is, of course, a variety of ways to handle these details, depending on the situation at your campus. The above method is given in an effort to make this article a source of specific suggestions which you can follow directly. It's obvious that unless you have a local organization's treasury to sponsor the dinner, or want to pick up the tab yourself, the reservations must be handled in a definite manner.

Finally the big evening arrives. This should be more than a day after you first started making arrangements, but not so long that everyone has forgotten what it's all about. It's not much of a job to plan the affair, but you should allow a couple of weeks for getting reservations (i.e., checks) and longer to line up the dean and department heads.

To make things look official (if that's an object) you can provide name tags and a sales talk on joining the ASEE at the door. Of course this, and other suggestions, might be ridiculous at a small school, for which obvious modifications would be made. However, here is a good chance to acquaint those who don't know with the reasons why an engineering teacher should belong to the ASEE.

Having entered the dining room, the people discover that there are place cards, diabolically arranged so that no one sits within reach of others in his department or known friends. This seems a bit arbitrary to say the least, but actually is probably the only way to get most people to sit amongst those they don't see every day. It is usually discovered that the strangers speak English, and a pleasant

conversation ensues, so that the dinner fulfills one of its aims, getting acquainted. Rather than having a mile-long table with you and the dean looking down from a platform at one end, a number of small tables can be used, so that each person meets four or five others quite closely.

Midway in the meal it can be announced that each person will introduce his neighbor on one side. This is an old gimmick that can be very boring, but it can also be entertaining if several people are primed to set the procedure off on a facetious vein. You can show how foolish the idea is at the beginning by introducing the gentleman at your side, who, your colleagues will be surprised to learn, is the dean of engineering.

Before they feel glued to their chairs, it is a good idea to let everybody get up for a short break, perhaps just after the introductions; it should not be necessary to lock the doors. You don't want to be mean and break up the conversation too soon, but eventually the program begins with a few brilliant and witty remarks by yourself.

The dean then gives a brief informal talk, concluding with an invitation for questions. The informality of the occasion is an excellent chance to ask him about his views and policies of the school, which are of real concern to the younger faculty. A good bull session ensues, but must almost invariably be primed at the beginning by planted questions. This is easily arranged if you have any friends on campus.

The many questions which can be so well answered in such a session, the opportunity for learning to know better your colleagues, and the enjoyment of a pleasant evening dining with interesting people make the comparatively slight effort required to plan the affair most rewarding. Try it at your school, and you'll see.

* * *

Here is your September YET-itude: Get the YETs met! The deed is a feed!

College Notes

Bell Telephone Laboratories, research and development organization of the Bell System, has announced the establishment of a fellowship program through which it will grant funds for students doing graduate study in electrical communications.

The awards are for study of one or two years, leading to a doctorate. Each fellowship carries a grant of $2000 to the fellow, and an additional $2000 to cover tuition, fees and other costs to the institution at which he chooses to study. Recipients of the fellowships will not be required to limit their study to electrical engineering, although the field of study and research must have a bearing on electrical communications. They may, for example, pursue various branches of mathematics, physics, chemistry, engineering mechanics and mechanical engineering. Fellows may make their own choice of an academic institution within the United States.

The **George Washington University** has announced the appointment of Dr. Jack Edward Walters to the position of Professor of Engineering Administration.

A combined 118 years of service at **Lowell Technological Institute** ended in June when Prof. Herbert J. Ball, Prof. James H. Kennedy, Jr. and Prof. Martin J. Hoellrich retired.

Survey of Nuclear Engineering Research*

By HERBERT S. ISBIN

Dept. Chem. Eng., Univ. of Minn.; Chairman, Subcommittee on Nuclear Engineering Research, ASEE Committee on Atomic Energy Education

Introduction

Continued advancement of our nuclear science and technology is dependent upon the training of an adequate supply of qualified personnel. The realization of this goal has been one of the objectives of the ASEE Committee on Atomic Energy Education. The Committee has participated in the stimulation of the training and education of engineers in our schools, governmental agencies, and in some industries. This paper concerns the progress being made by our universities and colleges in furthering nuclear engineering research. A report is given of a survey made of all member institutions of the Engineering College Research Council. As a part of its program, the ASEE Committee encourages institutions to develop their educational facilities in the over-all fields involving nuclear engineering, and to contribute to the advancement through basic research. The suggestions contained in this paper, however, represent only the opinions of the author. Currently, the Committee is undertaking a study and clarification of objectives in nuclear engineering and in the methods and scope of the training programs and curricula.

For the purpose of this survey, no formal interpretation of nuclear engineering was attempted. For example, it was indicated that nuclear engineering research topics include the prospecting, metallurgy and fabrication of nuclear fuels, claddings, and reactor structural materials; the design, construction, and operation of nuclear reactors, including experimental studies relating to heat transfer and fluid flow; the study of reactor components such coolants, shielding, instrumentation and control; separations; and fission product utilization and disposal. Almost any basic research problem might be related to some phase of nuclear engineering; therefore, only those researches which were initiated by a *direct* interest in nuclear engineering were sought for the listings in this survey.

Results of the Survey

A summary of the survey is given in Table 1 and the listings of typical research topics are given in Table 2. Table 3 lists the institutions indicating an interest in planning a reactor.

TABLE 1

SUMMARY OF SURVEY ON NUCLEAR ENGINEERING RESEARCH

No. of institutions contacted (all official members of the Engineering College Research Council—1953 Directory)		103
No. of replies		103
No. participating in nuclear engineering research		38
No. with reactor plans		30
* Planning—initial thinking	19	
* Planning—advanced stage	7	
Commitments made	3	
Reactors in operation	1	

* Presented at the Annual Meeting of ASEE, Penn State University, June 21, 1955.

* Of these two groups, ten indicated no current program in nuclear engineering research.

TABLE 2

TYPICAL NUCLEAR ENGINEERING RESEARCH

(Departmental listings are those noted by the Institutions)

Chemical Engineering Department

(including Metallurgical Engineering)

Processing of reactor fuels
Properties of special alloy systems
Radiation-induced reactions
Exchange of deuterium between steam and hydrogen
Catalytic combination of hydrogen and oxygen
Liquid metal research including boiling and condensation heat transfer, thermodynamic properties of vapor, solubility and stripping of xenon, forced and free convection, wetting and non-wetting conditions, gamma ray inspection
Two-phase flow including vapor transport, fluid slurries, hindered settling; pressure drop and heat transfer, and transient operations of natural circulation loops
Thermal diffusion in liquids
Drying of graphite
Swirling flow in spherical and cylindrical containers

Metallurgy

X-ray spectrographic analysis techniques
Recrystallization studies
Constitution of binary alloys of uranium
Scaling of zirconium in air at elevated temperatures
Nitriding of alloy

Civil Engineering

Physical properties of high density barytes-colemanite concrete
Wastes from an atomic energy plant, and disposal of radioactive wastes
Improvement of product for atomic shielding

Mathematics

Investigation of the stability of solutions to differential equations describing circulating-fuel reactors

Chemistry

(Survey of the chemistry departments was not included. The following replies received are pertinent.)

Study of the mechanism of oxidation of metallic sodium
Radiochemical studies of the fission products
Thermodynamics
Isotopic research

Food Technology

Use of fission products in food sterilization

Ceramics

Studies of methods of production of dense concrete
High temperature properties of some intermetallics
Thermal shock studies

Mining Engineering

Special techniques for mining low grade uranium ores

Mineral Engineering

Measurement by tracer techniques of the surface concentration of collectors on iron and lead minerals
Physical characteristics of uranium-bearing Chattanooga shales after thermal treatments

Geology

Use of geochemical techniques in the search for uranium

Aeronautical

Heat transfer

Electrical

Nondestructive testing by use of eddy currents

Physics

Nuclear energy levels; nuclear spectroscopy; neutron diffraction
Gamma ray diffusion, absorption, and slow motion capture studies
Effects of irradiation including damage in plastics and use of infrared in measuring effects
Neutron cross sections and inelastic scattering cross sections
Decay schemes for short-lived isotopes
Dielectric properties of ceramics
Structure and properties of thin metallic films
Slowing-down length of neutrons in reactor materials; neutron age in mixtures
Activation analysis of manganese in blood serum

Determination of gaseous products from a homogeneous reactor
Diffusion of radioactive gases through ceramic layers
Thermal methods for calibrating reactors

Listings Without Specific Departmental Headings

Exploration of the Moyie mountain area for uranium and other minerals
Beneficiation of low grade autinite by floatation methods
Study of field methods for determining the radium-uranium equilibrium in ore samples
Age determination of ore deposits
Uranium ore separations; and uranium and thorium feed preparation
Electrolytic separation of isotopes
Selective isolation of strontium-90, cesium 137 and barium 140
Separation and processing studies of reactor fuels, including studies at high temperatures, and fuels for fast breeder reactor
Study of evaporator for concentrating radioactive solutions
Production of heavy water
Protective coatings on metals; metal-ceramic bonding; high temperature materials for reactors and pyrometallurgy
Fabrication and cladding of fuel elements
Metal diffusion studies; gas-metal studies
Study of creep characteristics
Laminated shielding; admixtures for shielding; similitude relationships in shielding
Slowing down length of neutrons in hydrogeneous media
Reactor instrumentation
Investigation of reactor kinetics
Electromagnetic pumps
University heating
Temperature distributions in metallic heat sources
Effects of gamma radiation on rates of chemical reactions; sterilization of certain injectable pharmaceuticals; on plant tissues in culture; inactivation of viruses; chick feeding studies using irradiated foods
Effects of radiation in producing mutations in seeds; on combustion; sterilization of barley malt; bacterial metabolism; control of trichinosis; and the effects of chronic irradiation on bacterial cultures under conditions of continuous growth
Study of efficiencies in biological systems for the concentration of radioisotopes from liquid wastes
General utilization and packaging of gross fission products
Activation techniques and analyses
Irradiation services on electrical accessories; irradiation of glass, and industrial sapphires

TABLE 3

INSTITUTIONS CONSIDERING A REACTOR

Initial Thinking Stage

University of Arkansas
University of California (Berkeley)
Case Institute of Technology
University of Colorado
Columbia University
University of Connecticut
Cornell University
University of Denver
Georgia Institute of Technology
University of Illinois
Iowa State College
Kansas State College
University of Missouri
Northwestern University
Ohio State University
Purdue University
University of Southern California
A. & M. College of Texas
University of Texas

Advanced Planning Stage

Alabama Polytechnic Institute
University of California (Los Angeles)
University of Florida
Massachusetts Institute of Technology
University of Utah
Vanderbilt University
Washington State College

Commitments Made

Illinois Institute of Technology
University of Michigan
Pennsylvania State University

Reactors in Operation

North Carolina State College

Discussion of Results

The survey serves to reflect the active interests displayed by our universities and

colleges in participating in the development of nuclear engineering. More than one-third of the institutions have active research programs. The typical research projects listed in Table 2 outline the areas of current activities. In particular, the contributions that can be made by institutions not having a reactor are noteworthy.

The number of institutions considering a nuclear reactor for their educational and research programs is proportionately large. About 10% of the member institutions of ECRC consider their reactor planning in an advanced stage or have already made commitments. North Carolina State College is the only institution now operating a nuclear reactor.

The role played by the institutions in the development of nuclear engineering is not to be judged solely by their research activities or reactor plans. An additional 10% noted that they were active in one or more of the following ways:

1) Participants in an AEC National Laboratory
2) Developing courses in nuclear engineering
3) Staff members acting as consultants
4) Cooperating with industrial groups in the development of curricula and granting of degrees.

Suggestions

We recognize that almost all established engineering departments will make major contributions in nuclear engineering. As shown by Table 2, a larger share of the research is to be encouraged in the mechanical, civil, aeronautical, and electrical departments. Classification of research by subject material is the desired objective, and to some extent, this was incorporated in the departmental listings.

No attempt is made to analyze critically the progress being made in research. It is worthwhile, however, to note AEC's strong interest in high temperature chemistry and material problems (W. F. Libby, *Chemical and Engineering News,* **33**, 1944–5, 1955), and the general need for more research in problems relating to physical metallurgy, chemical separations, and fission product utilization and disposal. An effective way to feel the pulse of the unclassified and declassified research in all fields is to examine the current issues of *Nuclear Science Abstracts* (publication of the U. S. Atomic Energy Commission Technical Information Service).

The need for training and exposing faculty to nuclear engineering developments has received considerable attention by the AEC National Laboratories. Programs involve extended or summer work at the Laboratories. To a limited extent, even an exchange of personnel is possible. Staff members who have participated in these programs have been able to initiate and continue research at their institutions.

The laboratories required for nuclear engineering education and research have, for the most part, been directed toward a nuclear reactor. (Related research in nuclear physics is not considered in this paper.) High costs, availability of enriched fuel, and the AEC's high standards represent the factors which will self-regulate the number of institutional reactors. Serious consideration should be given to alternate proposals. Work with exponential piles and other subcritical assemblies provides excellent training. Further, the development of reactor kinetic simulators and analogs represents worthwhile objectives.

One might well anticipate that the major growth in nuclear engineering will appear in the irradiation and separation studies. The separation, utilization and disposal of radioactive products involve laboratory facilities which are highly desirable from standpoints of both educational training and research. In fact, the potential value of these installations rivals that of a research reactor. Thus far, only a few institutions have gone in this direction.

Institutional participation at the National Laboratories is provided, along with

equipment that can be used in the development and training of graduate engineers. Again, only a few institutions have taken advantage of the opportunities. Perhaps a reappraisal of a school's needs will show the advantages of developing one or a few special educational and research facilities on campus. The laboratory installations can then be utilized to achieve the broad perspectives generally desired in nuclear engineering.

Summary

The survey revealed that an encouraging proportion of our institutions is participating in nuclear engineering research, and that a corresponding large fraction has interests in a nuclear reactor. Several personal suggestions have been offered to emphasize the desirability of needs other than a reactor, and to note some of the opportunities available at our AEC National Laboratories.

College Notes

A class of 27 college engineering instructors from 23 states and two foreign countries studied advanced highway engineering this summer with the Institute of Transportation and Traffic Engineering of the **University of California, Berkeley.**

Street and highway construction is accelerating all over the country and is expected to continue to increase in the foreseeable future. The shortage will be even more acute when Federal legislation for better interstate highways is adopted. The summer instruction program at Berkeley was designed to aid other colleges and universities in expanding their teaching of highway engineering so that enough men can be trained to fill the many jobs now open in the highway profession.

Harold M. Froslie, head of the physics department at **South Dakota State College,** has been appointed acting dean of engineering. Dr. Froslie became acting dean July 1 and will serve until a new dean is appointed or until June 30, 1956.

Professor Edwin R. Shorey, College of Engineering's Department of Mining and Metallurgy, retired from the **University of Wisconsin** at the end of the 1954–55 academic year.

Dr. Willibald Weniger, **University of Alaska,** has retired as Head of the Physics and Electrical Engineering Department.

Science has become the greatest cultural force of our times, declared Dr. John Day Larkin, dean of liberal studies at **Illinois Institute of Technology,** in a Chicago commencement address. Because of its very complexity, a scientific and technological society requires some specialization, pointed out Dr. Larkin. But, he cautioned against too narrow a field of specialization which would make the individual lose sight of a common heritage and common problems as a citizen.

The **University of Florida** Department of Civil Engineering and the Prestressed Concrete Institute will sponsor the First National Prestressed Concrete Short Course October 10 through 12 at the Maritime Base, St. Petersburg, Florida. Theory and design will be discussed in lecture classes and papers will be presented by engineers in the prestressed concrete field.

Dr. Sydney Goldstein was appointed Gordon McKay Professor of Applied Mathematics in the Division of Engineering and Applied Physics at **Harvard University.**

Report on Survey Conducted by Committee on Recognition and Incentives for Good Teaching*

By HARRY W. CASE

University of California, Los Angeles

During the past year the Committee on Recognition and Incentives for Good Teaching undertook as part of its work a survey of the member collegiate institutions of the ASEE in an attempt to throw further light on the present status of teaching in the engineering colleges. It was hoped that this survey might furnish information which would be useful in attempting to determine, among other things, whether 1) teaching is receiving its correct proportion of attention in the multiplicity of professorial activities, 2) teaching is being encouraged as a profession, 3) attempts are being made to develop teachers, and 4) a good job of teaching is being rewarded adequately and appropriately.

The questionnaire was distributed to all members of the ASEE. From the first run 114 replies were received—69 from public institutions and 45 from private educational centers. A follow-up letter was sent on May 27 to 17 institutions which had failed to reply to the first distribution of the questionnaire. The results of this follow-up letter are not included in this report.

Table I shows the breakdown of the data by percentages. The data have been grouped into three categories—public schools, private schools, and the total group of schools. It may be advisable, when all of the information is received from the schools that failed to respond to the first survey, to attempt to make a regional analysis based on large geographical sections, such as East Coast, Midwest, etc. The regional breakdown used by the ASEE was utilized and found not usable because of the large number of regions involved and the small number of schools in a region, in some instances.

It will be noted in the examination of Table I that in numerous instances some of the questions were not answered. Unfortunately, it seems almost impossible

TABLE I

PERCENTAGES OF REPLIES

		Public	Private	Total
Question 1	Yes	39%	25%	33%
	No	58%	71%	63%
	No Answer	3%	4%	4%
Question 2	Yes	38%	28%	34%
	No	62%	64%	64%
	No Answer	0%	8%	2%
Question 3	Yes	56%	51%	54%
	No	34%	36%	35%
	No Answer	10%	13%	11%
Question 4 (a)	Yes	47%	31%	40%
	No	33%	45%	38%
	No Answer	20%	24%	22%
(b)	Yes	10%	13%	11%
	No	57%	54%	56%
	No Answer	33%	33%	33%
(c)	Yes	43%	44%	44%
	No	35%	36%	35%
	No Answer	22%	20%	21%
Question 5	Yes	16%	18%	17%
	No	81%	73%	78%
	No Answer	3%	9%	5%
Question 6	Yes	61%	60%	60%
	No	36%	38%	37%
	No Answer	3%	2%	3%
Question 7	Yes	71%	75%	73%
	No	16%	18%	17%
	No Answer	13%	7%	10%
		N = 69	N = 45	N = 114

*Presented at the Annual Meeting of ASEE, Educational Methods Division, Penn State University, June 20, 1955.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

COMMITTEE ON RECOGNITION AND INCENTIVES FOR GOOD TEACHING

Mail to: Professor Harry W. Case
Department of Engineering
University of California
Los Angeles, California

QUESTIONNAIRE: Recognition and Incentives for Good Teaching

(1) *Local Committee*

Within the last two years has a committee at your institution made recommendations on the problem of recognition and incentives for good teaching with emphasis on good teaching as distinct from other activities? Yes..... No.....

(2) *Attention to Good Teaching*

Has your institution developed any good methods for calling attention to good teaching other than through rank and salary promotions? Yes..... No.....

(3) *Publicity on Good Teaching*

In publicity and house publications does your institution place emphasis on good teaching at least equal to the emphasis placed on each of the following: plant, research, science and technology, and social or professional activities? Yes..... No.....

(4) *Periodic Evaluation of Individual Growth*

Does your institution require a periodic report on activities reflecting growth of each member of the teaching staff to be made by:

(a) the staff member? Yes..... No.....
(b) a committee? Yes..... No.....
(c) an executive? Yes..... No.....

(5) *Consultation with Teachers on Effectiveness*

Does your institution require a periodic consultation with each teacher on the subject of his teaching effectiveness? Yes..... No.....

(6) *Written Policy Statement*

Is a written statement of policy on rank and salary promotions for the teaching staff available to the staff at your institution? Yes..... No.....

(7) *Weight on Teaching Effectiveness*

When your institution considers a member of the teaching staff for rank or salary promotion, do you believe that in most instances more than half of the weight of decision is based on the individual's relative teaching effectiveness? Yes..... No.....

Institution.....

Name.....

Position.....

Date.....

to design a questionnaire of this nature which will cover satisfactorily all possible cases, and make sense to the individuals answering it. Considerable improvement undoubtedly can be made if such a survey is undertaken again.

The members of the Committee would like to thank the very large number of deans who took the time to fill out the questionnaire personally, and who in many instances made written comments on the areas being considered. It seems desirable to go over the seven questions comprising the questionnaire and to call to your attention some of the results and the comments made by the various institutions.

(1) *Local Committee*
Within the last two years has a committee at your institution made recommendations on the problem of recognition and incentives for good teaching with emphasis on good teaching as distinct from other activities?

A higher percentage of publicly owned schools answered that they had committees than did privately owned schools. The total is almost two to one of "no" answers to "yes" answers. The remarks range from apologies for poor and inadequate college committees to the statements of those who pointed out that they had had committees in the past but did not at present. A comment from one of the schools indicated that they believed they were small enough to do without committee action. Still another dean commented that the entire faculty of professors constituted the committee. Other comments were that it was primarily the young teacher who was interested in this objective; and another indicated that teaching was only one of six fields of emphasis.

(2) *Attention to Good Teaching*
Has your institution developed any good methods of calling attention to good teaching other than through rank and salary promotions?

Again, public institutions were somewhat better in this respect than the private ones. Only 34% of the schools indicated that they had some method of calling attention to the individual instructor; 64% indicated that they did not. One college has an annual $1000 award for "able and inquiring teaching," and another gives a medal. Comments ranged from the desirability of such a system if it could be worked out to the feeling that it was extremely difficult to develop such aids.

(3) *Publicity on Good Teaching*
In publicity and house publications does your institution place emphasis on good teaching at least equal to the emphasis placed on each of the following: plant, research, science and technology, and social or professional activities?

The results from this question are somewhat more encouraging. Of the overall total, 54% place emphasis on good teaching equal to other activities; 35% do not; and 11% did not answer the question. Comments on this question ranged from one which stated, "Teaching ability is emphasized to the exclusion of some of the above," to those which remarked, "It is difficult to publicize," or "It cannot be measured." "The implication of this seems to me to be ridiculous," was one blunt reply.

(4) *Periodic Evaluation of Individual Growth*
Does your institution require a periodic report on activities reflecting growth of each member of the teaching staff to be made by:
(a) the staff member?
(b) a committee?
(c) an executive?

A glance at Table I will reveal that the "did not answer" group increased mark-

edly in this question—the implication being that the answers were not needed in all sections of the question. Apparently, the way the question was designed confused many of the individuals completing it. Forty per cent of the group indicated a "yes" to section (a), that the staff member was required to make a periodic report on his activities; 38% answered "no"; and 22% did not answer. Eleven % of the total required such a report to be made by a committee, while 56% did not, and 33% failed to answer. Evaluation by an executive received 44% "yes" answers against 35% "no" replies, and 21% did not answer. The comments on the question ranged from the statement that the staff member was "expected to" on item (a) to "indirectly" on item (e). One dean pointed out that the committee was rather informally organized by department heads and deans. Another said that the executive committee made such a report annually, and one pointed out that steps are being taken at present to compile personnel record folders which will contain evaluation and progress reports.

(5) *Consultation with Teachers on Effectiveness*
Does your institution require a periodic consultation with each teacher on the subject of his teaching effectiveness?

The "yes" responses to this question showed a very heavy drop, percentagewise. Only 17% of the schools responded affirmatively, while the majority—78% —answered "no." Five per cent did not reply. The majority of comments indicated that when consultation was held with teachers on their effectiveness, it was done informally. In some instances this occurred only if the teacher was "low" or a young teacher just getting started. One school stated that since they were small, they had the advantage of being familiar with the work of all individuals and that they consulted with their teachers. Another school commented that they had done so in the past, but did not have definite plans for the present year.

(6) *Written Policy Statement*
Is a written statement of policy on rank and salary promotions for the teaching staff available to the staff at your institution?

Sixty per cent of the total schools reported that they had a written policy statement on rank and promotions available to faculty and staff. Thirty-seven per cent did not have such a statement available, and 3% failed to answer the question. Comments on this question varied all the way from the statement of one dean who said, "Yes (my own)" to those who have them in preparation at present. Probably one of the useful indications of the trend was the comment from a dean who wrote alongside the question that he would like to receive a copy of such a statement from an institution which had one.

(7) *Weight on Teaching Effectiveness*
When your institution considers a member of the teaching staff for rank or salary promotion, do you believe that in most instances more than half the weight of the decision is based on the individual's relative teaching effectiveness?

In the responses to this question, private institutions fared somewhat better than the public ones. Seventy-three per cent of the total answered "yes" that they believed that more than half the weight of the decision is based on the individual's teaching effectiveness, 17% answered "no," and 10% did not answer the question. The comments in many instances reflected the conscientious viewpoint of the answerer by qualifying the answer with the statement that this was an ideal to be sought but often varied in the actual cases. One individual, for example, who refrained from answering, stated that he would like to think so, but that he was

not sure. Another one said, "Sometimes 'no' and sometimes 'yes.'" Still another one pointed out that there were ten factors involved in an appraisal at their institution, and that teaching accounted for 35% of the weight.

Looking at the answers to the questionnaire as a whole, it seems that "good teaching" is a quality which is desired by most institutions but which is found difficult to measure. The number and quality of publications a man has to his credit for a year, the number of committees on which he serves ably, the number of hours he teaches, the amount of time he devotes to civic activities, etc. can be measured more definitely. Colleagues can assess the value of the publications, the work done by the committee and how much of it the individual is responsible for can be ascertained, the schedule of his classes is easy to determine, and his civic activities are not too difficult to find out about; but how does one determine *objectively* how "good" a teacher a man is? This seems to be the crux of the problem. Students can be polled, but can student opinions of teaching effectiveness be termed anything but subjective? Other teachers' opinions can be obtained, but these are not only subjective but also are based mainly on hearsay from students, either directly or by inference. The amount of difficulty students have handling a course can be considered only in relationship to the background of the students—some may be ill-prepared and some may not have the basic aptitude. Effective teaching is, therefore, a quality or ability which needs to be studied more thoroughly in order that an objective method of evaluating it may be determined.

Yet, in spite of these problems, it is obvious that engineering colleges over the nation are not only aware of the necessity for recognition and incentives for good teaching, but individually are attacking the problem. Undoubtedly, there is much to be done; however, the recognition that other schools have not only attempted to solve their problems but have worked out methods to do so should do much to spur on others. It is apparent that if the engineering colleges which are unable to feel satisfied with their efforts along these lines were to concentrate on establishing for their schools policies and procedures which would include attention and publicity to good teaching, periodic evaluation of individual growth, and a written statement of policy on rank and salary promotions giving definite weight to teaching effectiveness, there would of necessity be a great upsurge in the recognition and incentives for good teaching.

Perhaps now that we know there are schools leading the way in these efforts, an interchange of information could take place which would reveal many of the pitfalls that others have surmounted. One area in which public exchange of information could be useful is in the development of a written policy statement concerning rank and salary promotions. Another is the ways and means of affording publicity to good teaching. Practically all the factors touched on in the questionnaire are important to other schools; and if those who have explored these byways will make known to others their results, much will have been accomplished.

Aim for Ames in 1956

What Industry Expects of the Young Graduate Engineer*

By JOHN GAMMELL

Director of Graduate Training, Allis-Chalmers Mfg. Co., West Allis, Wisconsin

PART I

I had occasion about a year ago to ask some prominent engineers and industrialists what they thought could be done by our schools to prepare better engineers. I will give you, briefly, some of their ideas plus a few of my own opinions.

As you might expect, their suggestions strongly mirror their own interests. The ideas are good but present no obvious unified point of view. Collectively, they indicate a need for adaptable people with broader educations. They emphasize, too, that college is but a prologue to a useful career. A good education is one that stimulates a man to continue growing in whatever direction is necessary.

This can best be illustrated by a few quotations from these letters.

Practical Engineering Must Never Lose Sight of Economic Factors

Those in management believe a professional engineer must never lose sight of the economic factors. For a man who has to carefully scan the profit and loss statement every month, such ideas are far from trite, though they may seem that way to the rest of us. Here then is what was on the mind of an industrialist who started his own business and carried it on to success.

"From the standpoint of industry, I believe an engineering education should include an economic analysis of an engineering problem stated in terms of material and labor reduced to dollars and cents."

A few years ago, industrial magnates were everywhere deploring that our youth were being led down the road toward that "bugaboo" of the rugged individualist—the welfare state. They had a point too. One of them quotes an excerpt from the American Ordnance Association published in 1948 under the title of "Are We Owed a Living?" in which he shows that it costs the nation's taxpayers $25,000 (as of 1948) to educate and protect a child from the time he enters kindergarten until the time he graduates from college. The emphasis he makes is, that these students ought to be made aware of how much they owe other people; that they aren't aware of it and aren't properly grateful.

Continued Professional Development

Few comments are more monotonously repeated among engineers than the one about the need for professional development; I could hardly leave such a quote out of my paper. Here is a typical one from a scholarly elder statesman with a genuine interest in young men.

"There are however changes that appear on the horizon that will make it necessary to consider the engineer as a truly professional individual. The training of such professionals will require a broader education than the conventional four-year course in engineering provides. It would appear therefore that consideration must be given to a broader appraisal of engineering education regarding professional development, and it must be

* Presented at the Annual Meeting of ASEE in the Joint Session of the Mechanical Division and Relations with Industry Division, Penn State University, June 21, 1955.

clearly and definitely understood that there is a difference between the technologist and the technician."

Somewhat contrary to this, a chief engineer of high stature has this to say:

"The present four-year course is ample. I do not favor a five-year course or advanced courses for general engineering work. I favor training men in the location where they will work as more beneficial."

Personally, I feel the training a man gets just by working in the location of his job is limited. It seems to me that this is merely learning the job routine. For instance, if I wanted to train a turbine designer, I would see that he erected a turbine; tested one; understood power house procedures; etc., as well as just knowing design calculations, which he will assuredly learn well since he'll do them the rest of his life.

The Experienced Older Engineer Needs Different Skills Than the Beginner

Comments from several heads of engineering and research sections indicated that success as engineers was not due to technical skill, but rather to such elusive factors as personality and professional development. This is another of those highly overworked statements among engineers, yet the next quote fascinates me —it's clear-cut.

"Generally, it is safe to say that technical ability and proficiency has its greatest value early in the career of an engineer. At that time, it is a substitute, often a very superior substitute, for experience. It can even substitute for judgment and personality. With the years, however, and with longer practice in engineering, the scope of the individual is broadened. Technical ability loses its importance and the personal characteristics of the engineer play an ever-increasing part in determining his progress."

A successful executive who is now in the process of establishing his sphere of influence is most concerned that young engineers continue to grow professionally. He has this to say:

"An engineer must never stop educating himself in the field of modern industry.

"After the future engineer in industry completes his formal engineering education, he should consider the planning of time for additional studies so that he may continue to broaden his background."

It is an important idea, and I intend to close with a quotation on the subject of continued education.

Research Heads Want Fine Basic Knowledge and Engineering Creativity

Research people are full of ideas and, traditionally, are supposed to be able to improve anything. Here is a remark by a research head (a Ph.D.) right up to date on the latest in curricula ideas. He's critical and points out:

"In the last forty years industry has changed more perhaps than in the previous hundred years, yet it has been reported that in most engineering colleges the curricula in at least civil, mechanical, mining, and electrical power engineering have not changed materially in that time. Since engineers are trained primarily for industry, it would seem that with the revolutionary changes going on which make industrial processes more scientific and more highly technical, the engineering courses should have been changed to adapt them to industry's needs."

To accomplish this, he proposes a thorough four-year, undergraduate drill in fundamental science and general engineering.

Another head of a development and research organization is concerned with the creativity of young men. He states,

"I would say that one of the real problems facing industry today is securing engineers not only trained to think along the lines of the so-called 'engineering method' but also to secure men who have some basic training in creative methods."

When talking creativity, I sometimes have a "puckish" tendency to remark that what we need is some good maintenance technicians. There are so many electronic

devices and other gadgets (dreamed up, no doubt, by creative individuals) around my house now that I can't get repaired, I'm a bit disturbed about getting any more.

Humanities Should Be Stressed

There is a well-known school of thought among management people which stresses the need for men with a better understanding of the humanities, cultural subjects and business; in other words, knowledge other than scientific. I suspect they feel we may all end up as a special kind of robot requiring a nutritional pill or a health shot now and then to keep us mechanically creating all those machines we have trouble maintaining. They might even be able to give us these health shots and nutrition pills with an oil can, thus further extending the allusion. Here are two quotes on the humanities, one by an old timer with experience and influence,

"Courses in Public Speaking, Business Letter Writing, Commercial Law and Essentials of Advertising could be advocated as electives for engineers."

another by a prominent consultant in management:

"The recognition of humanities is desirable. Too little thought is given to the developing of imagination and creativeness."

A Young Engineer Speaks on Dangers of Specialization

The present day trend toward the training of strictly technical specialists is deplored by a young man climbing the ladder of success. This young man, who is just starting out on his professional career, but who already has attracted much attention for his leadership qualities, suggests

"that juniors and seniors be more positively encouraged to read technical publications, attend professional lectures, and generally begin to integrate themselves into the engineering community. (Professional societies.)

He continues:

"The great shortcoming of engineering training lies in its failure to direct the student's attention to studies complementary to his technical courses. Often, we graduates discover ourselves to be, a year or so out of college, skilled in a trade, conversant with the phenomena of science, staunch of character, sociable, and somewhat uneducated. We are ill-prepared for leadership of—or even intelligent participation in—the society technology has developed."

This particular young engineer makes out quite a case against those who want too early specialization. He quotes rather learnedly from Jacques Maritain, a Harvard philosopher.

"Specialization is more and more needed by the technical organization of modern life, yet it should be compensated for by a more vigorous general training, especially during youth. If we remember that the animal is a specialist, and a perfect one, all of its knowing-power being fixed upon a single task to be done, we ought to conclude that an educational program which would only aim at forming specialists ever more perfect in ever more specialized fields, and unable to pass judgment on any matter that goes beyond their specialized competence, would lead indeed to a progressive animalization of the human mind and life."

Along these lines it is pointed out by some that the honeybee is a perfect example of the result of a specialized society. It has no other objective and no other function than one assigned to it by reason of birth. It carries this on with great perfection until it dies. Its society is perfect, but it isn't human and it doesn't advance.

From the foregoing, it is easy to see that people feel deeply about what the young engineer should be like and the training essential for engineering success. The most interesting part is the diversity of requirements. Because of this, a friend of mine, deeply interested in the training of engineers to meet tomorrow's challenge, feels that 5 or 6 years of academic training is essential for the engineer of the

future. Whether the extra one or two years turns out to be in graduate school or undergraduate school; whether the humanities are added in the beginning or interspersed throughout the course in college, is something to be debated, but the final result is, he thinks, inevitable—we need 5 or 6 years college work. At the same time, however, one cannot escape the notion that if industry wants specialized people, they should do more than on-the-job training which is frequently not real education at all, but just learning the job. The honeybee, of course, knows its job, but, knowing nothing else, it doesn't "grow."

Part II

Although the survey did not enlighten us as to what industry expects of the young engineer, it nevertheless made us aware that industry likes young engineers to be in their own image.

A careful analysis of the replies, however, shows some agreement in the area of intangibles. They are not factors which can be taught in specific courses, but rather the young man imbibes these ideas from the environment (home, community, and school). The ideas are not new, but because of the pressure on the schools to present the ever growing mass of technical knowledge, the realm of philosophical thoughts is neglected. Yet it is the young engineer's philosophy toward work and dealing with people that looms so large in his progress toward success.

I shall briefly discuss some of these factors as I see them.

The Man Makes the Job

There is a philosophy found among many young men and also in the college faculty that would seem erroneous. It arises from a notion quite prevalent in professional circles, too. This is the notion that jobs must somehow measure up to the man—that it is unethical to employ a talented, high grade man and put him on a task not in keeping with his training and skills. Doesn't a feeling like this indicate that we have missed the true meaning of education? The true professional, the creative man, the man of imagination can take any job, no matter how menial, and turn it into an activity which measures up to his own standard. Thus, we have the blacksmith becoming a metallurgist; the carriage maker becoming the automotive engineer; the crystal set radio maker becoming the electronic guided missile specialist; or, to go further into history, the laboratory helper discovering some of the basic laws of electricity and magnetism.

It has been facetiously remarked that a good man given a broom and asked to be responsible for keeping the place clean will bring a lot to the janitorial business. There is some merit to this point of view, since a casual glance at developments in the field of janitor's supplies indicates that a great deal of fine engineering has gone into the business. While it is stretching the point, an engineer should have the enthusiasm and the confidence to say, "Give me any job—any job at all—and I will make something of it, for that's the way I've been educated."

Benjamin Franklin must have had thoughts like these when he walked the streets of Philadelphia with a loaf of bread under his arm, and Ben Franklin illustrates exactly the point I mean to make—you could give him a job, any job at all, science, politics, the printing business, or anything else, and his attitudes and abilities were such as to bring it to a high order of usefulness and esteem. We are not a status quo society; we are a moving, growing society! Things of today that amount to nothing are going to be of top importance tomorrow. To meet the rapid changes in our economic and social life, highly adaptable men with imagination are needed.

Much of the present talk, therefore, on better utilization of engineers—though it must be admitted not all of it—seems to be as out of place with the needs of our dynamic new world as a group of revived

Roman Senators discussing Ceasar's Empire.

Loyalty

We often receive complaints that the young men of today are not loyal to their employers. This lack of loyalty might arise from the poor utilization idea. To exaggerate a bit, if they cannot immediately walk in and become Manager or Chief Engineer, they feel frustrated and become a "bad apple in the barrel." They don't like the place and, seemingly, don't want anyone else to like it either. They should realize that when they agreed to sell their services, they also agreed to be loyal to their employer. And loyalty means that they will do the best they can, and neither do or say anything that will be of detriment to their employer Communicating unconstructive dissatisfactions to fellow workers should be avoided.

This does not mean that nothing should be mentioned about problems and gripes. The young men will have to take over management in later years; they should think about the difficulties now.

Management Ability Needed

According to some authorities, approximately one in every two graduates from an engineering college, today, is destined to be in an executive position in the not too distant future, while many others, although not executives, will be in a supervisory capacity and be responsible for subordinates almost immediately. This being true, an understanding of a few basic principles of management is in order. A successful supervisor becomes a receiver of ideas rather than a dispenser of ideas—a servant rather than a master. He wields influence by asking questions and receiving information, rather than by giving orders and acting as a "know-it-all" (an irritating business to a subordinate who probably knows more of the detail than his boss.) He should take a genuine delight in his subordinates' successes—might even brag about them a little; he finds satisfaction in helping others out of trouble; he defends his subordinates vigorously; he expects nothing but the warm glow within himself when discovering a job well done by a subordinate and thereby discovers the real law of compensation in human affairs. I think this is well summed up in the quotation from the *BIBLE* (Mark 9:35)

"If any man desire to be first, *the same* shall be last of all, and servant of all."

The Courage to Stand by One's Ideas

To have the courage to propose ideas and to defend them should be an integral part of a young man's training. (Does anybody really like a yes man?) He should not do this, not only because he will eventually become older and assume more responsibility, but because he will have the responsibility even as a young man to influence his superior toward better and more modern methods. Isn't this a traditional requirement for young men? It is a phase often neglected during the training of young engineers. To illustrate my point, I would quote from an article in the January–February 1955 issue of *Harvard Business Review*. Speaking of executive engineers, it says:

"They get too busy with the technical details to worry about developing people—and this is more true of able engineers than of mediocre ones. Since their ability and knowledge is great, assistants lean on them for ideas and decisions to too great a degree. The junior men do not learn to fight hard enough for chances to try their schemes, and too slowly develop a sense of responsibility for the wrong and right. Having too little experience in making mistakes, they are also slow in developing the courage to risk mistakes and defeats—an indispensable quality in modern management.

"The delegation of authority and risk taking seems to be better understood by nonengineers. It is difficult for almost all bosses to let the man of less experience and ability make decisions; it looks like a silly risk."

While a few may temporarily make fine careers by constantly saying "Yes" to the boss, and perhaps "No" to the help, it is a method which sooner or later will lose the respect of everyone. To fight for your ideas is a mark of any strong person. It is a hazardous operation however, and must be accompanied by a keen sense of discrimination, as it can easily ruin the career of a promising young man, yet is a risk that he must be taught to take —there is no other course.

Profit and Loss in Business

Any man in business must have some appreciation of the importance of the profit and loss statement. From a business standpoint, what can be more important? The story is told of an important executive who was being pushed by his President to operate an outlying plant in a manner different than he wished. After quite a bit of debate over the subject, the Plant Manager said, "Mr. President, if I do what you want me to, and the plant is in the red next year, will you send me a letter of congratulations?" Another over-simplification, no doubt, but the meaning is clear—you have to be in the black in any business operation, and it is your responsibility to see that your superior knows and thoroughly understands the implications of his orders. If you are in the red, you will be blamed for it regardless of what those orders happen to be. It is like the lines of a familiar poem:

Laugh and the world laughs with you,
Weep and you weep alone,
For the sad old earth must borrow its mirth,
But has trouble enough of its own.

Understand the Boss's Problems

Many young men become discouraged when they present an idea to the boss and his attitude is doubtful. Why shouldn't the boss be doubtful? The idea is new; he therefore asks questions. To the young engineer who has lived with his problems a long time, this irritating question period seems pointless. He assumes that his superior is negative with regard to his project. He becomes unnecessarily discouraged.

Continued Education

Continued education is important but even Thomas Jefferson sometimes had doubts about certain kinds of education. At one time he said:

"They (academies) commit their pupils to the theatre of the world, with just taste enough of learning to be alienated from industrious pursuits and not enough to do service in the ranks of science."

But does anyone really think too much education is possible? To believe this is, in a way, like saying it is possible to be too wise. Students, however, should be made to realize that going to school without a goal is a hollow thing; and that many a bum on a park bench is well informed. Wide knowledge is not necessarily a mark of men of great accomplishments. Someone has said that a good definition of an educated man is one who knows a little bit about everything (quite an undertaking) and a great deal about one thing.

Motivation

It is a characteristic of an engineering education that it conveys to a man a respect for facts and objective thinking. Respect for facts may prove detrimental when a man is called on to make decisions. A recent article on management pointed out that by the time all the facts have been gathered, the need for decision-making has evaporated. After all, many decisions are made on the basis of how we feel —in short, our emotions rather than a complete factual analysis. It has been facetiously remarked, "Any married man knows this, but do engineers?"

A young engineer is certainly most valuable who understands that the drive to *do* something worthwhile is more important than whether or not he *knows* something worthwhile. The will to get there is the vital part. To repeat the words of an English poet:

Grant us the will to fashion as we feel,
Grant us the strength to labor as we know,
Grant us the purpose, ribb'd and edged
With steel—to strike the blow.
Knowledge we ask not—knowledge thou has lent,
But Lord, the will—there lies our bitter need. . . .

Conclusion

In closing, let me quote from the writings of James Hilton, the creator of that fine literary character, the schoolmaster, Mr. Chips. It is entitled "The Day Mr. Chips Got Mad" and might be appropriate to this discourse on what industry expects of the young engineer. It starts out with something from Epictetus—

"'It is impossible for anyone to begin to learn what he thinks he already knows.'

"Mr. Chips wasn't often cantankerous, but he did once (and perhaps a bit unfairly) let fly over a letter from a parent containing the sentence: 'After my son finishes his education, he will enter my business.'

"It was the whole idea of 'finishing an education' that did it. 'Good heavens,' he exclaimed, 'does the fellow think education is like measles—something you get over while you're young so that you don't have to be bothered with it ever afterwards!' And then came the quotation from Epictetus, as above."

I daresay Epictetus, like Mr. Chips, exaggerated a little to make a point. But it is a point worth making—that education, in the deepest sense, is continuous and lifelong and in essence unfinishable; and it is true also that what we think we already know is often less helpful than the desire to learn.

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Teaching Tips

The cooperative spirit between student and teacher, so necessary for good instruction, is greatly enhanced when the teacher knows the students as individuals. Often this is not accomplished until too late in the course to be really effective.

One way to accelerate this acquaintance is to ask (at the first class) each student to prepare a short biography for the benefit of the instructor. These should then be read and studied by the instructor. They aid him in associating names and faces and in treating these names and faces as an individual with normal ambitions, strengths, and weaknesses.

Such biographies should include background experiences in schools, army or industry rather than dates. Likes and dislikes are also important, as well as weaknesses that are recognized by the student.

This plan might back-fire unless the instructor is sympathetic and wise in the use of the information given. Properly used, however, it has much to offer.

FRED H. PUMPHREY

College Notes

Dr. Paul Weber, Professor of Chemical Engineering and Director of the School of Chemical Engineering at the **Georgia Institute of Technology,** has been appointed Dean of Faculties.

Dr. George V. Smith was appointed to the Francis Norwood Bard Professorship of Metallurgical Engineering at **Cornell University.** Dr. Smith has taught graduate night courses in metallurgy at Brooklyn Polytechnic Institute and was a research metallurgist with the U. S. Steel research laboratory.

Two new graduate courses in nuclear engineering are being offered at **Oklahoma A. & M.** during the 1955–56 academic year. The college has an arrangement with the Argonne National Laboratory for graduate students to take their courses at Oklahoma A. & M. the first year and work for the Atomic Energy Commission at Argonne the second year. These graduate students will write a master's thesis on the basis of their work at Argonne and receive an M.S. in chemical engineering at Oklahoma A. & M. with a nuclear engineering option.

Dr. Robert B. Mesrobian was promoted to Professor of Polymer Chemistry at the **Polytechnic Institute of Brooklyn.** He was also named Assistant Director of the Polytechnic's Institute of Polymer Research.

Lamme Award—1955—Vannevar Bush

To VANNEVAR BUSH *for his work on operational methods of circuit analysis, on electrical computing machines, and on servo-mechanisms, which pioneered the introduction of these several subjects into engineering education, and also in recognition of his leadership in developing the pattern for government support of research in universities that has had such a profound effect on engineering education in the last decade, we award this twenty-eighth Lamme Award.*

VANNEVAR BUSH, electrical engineer, executive, was born at Everett, Mass., March 11, 1890, son of Richard Perry and Emma Linwood (Paine) Bush. His father was a Universalist clergyman.

Dr. Bush was graduated from Tufts College with the degree of B.S. and M.S. in 1913 and later took graduate work at Harvard and the Massachusetts Institute of Technology, both of which awarded him the D. Eng. degree in 1916.

He was with the test department of the General Electric Co. in 1913 and the inspection department of the U. S. Navy in 1914, instructor in mathematics at Tufts College in 1914–15, and assistant professor of electrical engineering there in 1916-17. While the United States was engaged in the First World War he carried on re-

search work in connection with submarine detection for a special board of the U. S. Navy. In 1919 he returned to the Massachusetts Institute of Technology as associate professor of electric power transmission and was made professor in 1923, becoming Vice President of the Institute and Dean of its school of engineering in 1932. He held these positions until 1938 when he was elected president of the Carnegie Institution of Washington, D. C.

In 1940, while still retaining his position with the Carnegie Institution, he was appointed by the President of the United States as Chairman of the National Defense Research Committee. A year later Dr. Bush was made Director of the newly established Office of Scientific Research and Development charged with the duty of mobilizing the scientific effort of the country. He continued in this post until the OSRD was terminated in December, 1947.

As chairman of the NDRC and later as Director of OSRD, Dr. Bush was a central figure in the development of nuclear fission, which culminated in the use of atomic bombs to bring the war to an end. His official connection with the project began in June, 1940, when the earlier constituted Uranium Committee was made a subcommittee of the newly created NDRC. As a member of the Top Policy Group headed by the President and as chairman of the Military Policy Committee, he shared responsibility for the determination of policy throughout the program, continuing in this work after the task of administration and development had been taken over by the Army in 1943.

President Roosevelt in the fall of 1944 called on Dr. Bush for recommendations on ways whereby the lessons learned through the OSRD in time of war might be applied in time of peace "for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living." In response to this request, Dr. Bush prepared a report, issued in July, 1945, under the title "Science, the Endless Frontier," which drew on studies made by four committees of eminent scientists, engineers, and educators, and made specific proposals for the consolidation and utilization of the scientific skill of the nation for the general good. In July, 1946, Dr. Bush was appointed Chairman of the Joint Research and Development Board of the War and Navy Departments to carry out "a strong, unified, integrated, and complete research and development program in the field of national defense." The National Security Act of 1947 replaced the JRDB with the Research and Development Board of the National Military Establishment; Dr. Bush served from September, 1947, to October 15, 1948, as the first chairman of this organization.

Dr. Bush has received patents on gaseous-conduction devices and on cathode arrangements and coatings for grid-controlled arcs. His inventive interests have for years been focused on the application of mechanical and electronic means to reducing the burden of computation, calculation, and repetitive routine on man's intelligence. One expression of this desire is the network analyzer which, with staff members of the Department of Electrical Engineering, he developed at the Massachusetts Institute of Technology in the late 1920's.

Another and more important result of Dr. Bush's interest in this direction is the differential analyzer, construction of which began under his direction at the Massachusetts Institute of Technology in 1935, and which is a radically different and improved advance over the first machine of the sort, which he developed there in collaboration with the electrical engineering staff in 1930. The new machine, weighing 100 tons, combined some 2,000 electronic tubes, several thousand relays, about 150 motors, and nearly 200 miles of wire to provide solutions of the differential equations expressing mathematical problems involving as many as 18 variables. Problems in atomic physics, acous-

tics, ballistics, structures, and electrical machine transients are representative of the tasks for which the analyzer is designed.

Other devices such as the rapid selector which scans and selects wanted items from microfilm, and the justifying typewriter which produces typescript with an even right-hand margin in one operation, have resulted from Dr. Bush's inventive interest in making machines do more of the pseudo-intelligent work of the world. In the *Atlantic Monthly* for July, 1945, he wrote speculatively and fancifully of a hypothetical machine called the "memex," which, utilizing components of this sort, would serve as an extension of man's memory, bringing wanted items before him on a viewing screen by means of an associative index, and permitting him to review at the touch of a finger all his accumulation of data on a desired subject. Dr. Bush's independent research work on the justifying typewriter helped in the develpment of a photographic type composing machine called the "Photon," which uses a photo-electric process rather than movable type for printing.

Dr. Bush is the author of "Operational Circuit Analysis" (1929) and many technical articles, and the co-author, with William Henry Timbie, of "Principles of Electrical Engineering" (1922). A collection of his papers and addresses was issued in 1946, under the title "Endless Horizons." His most widely known publication is "Modern Arms and Free Men," a discussion of the role of science in preserving democratic institutions.

Dr. Bush holds honorary degrees from 19 universities and colleges, has been presented with a number of medals and awards for his achievements, and has been elected to honorary membership in many distinguished learned societies. He was married to Phoebe Davis of Chelsea, Massachusetts on September 5, 1916, and has two sons, Richard Davis Bush and John Hathaway Bush.

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George Westinghouse Award—1955—
Robert Roy White

To ROBERT ROY WHITE *for his inspiring efforts in the interests of better teaching; for his ability to develop new ways of presenting engineering principles; for his capacity to stimulate students and his associates; for his extension of engineering teaching to practicing engineers; for the presentation of his research before technical meetings; for significant publications in several areas of endeavor; for contributions to the administration of graduate and undergraduate programs; for devotion to the development of the capacity of young engineers, we award this tenth George Westinghouse Award.*

ROBERT ROY WHITE was born in Brooklyn, New York, on March 1, 1916. He received a B.S. degree in Chemical Engineering from the Cooper Union Institute of Technology in 1936. After a year of night school work at the Polytechnic Institute of Brooklyn, 1936–37, he enrolled in the University of Michigan, receiving the M.S. degree in Chemical Engineering in 1938 and the Ph.D. degree in 1941. He also attended the DePaul Law School at night in Chicago, 1941–42.

His industrial experience includes employment with the Calco Chemical Company, Dow Chemical Company, Standard

Oil Company of California, and Universal Oil Products Company. He is a registered engineer in the State of Michigan and engages in active consulting work in the field of distillation, reaction kinetics, and transfer operations.

He initiated his teaching career as an Instructor at the University of Michigan in 1942, reaching the status of Professor in 1950. His promise as a young teacher was recognized by the University of Michigan, in 1946, through the Russell Award.

During his teaching career he has taught courses covering practically all of the material which one finds in the modern undergraduate curriculum in Chemical Engineering. He has been active in modernizing the undergraduate work and in developing several new graduate courses in chemical engineering. These embrace material in rate processes, reaction kinetics, azeotropic and extractive distillation, and separation operations. He is an active contributor to the curriculum committee of the Engineering College, as well as a member of the Executive Boards of the Horace H. Rackham School of Graduate Studies and of the Extension Division. He has been chairman of the committee which originated the Nuclear Engineering program of the Engineering College and is currently chairman of the committee which has developed the new Science Engineering program.

Professor White has long been active in research. His publications number about sixty to date. In 1946 he received the Junior Award of the American Institute of Chemical Engineers for his contributions to Chemical Engineering literature.

He married Elizabeth Clark of Niagara Falls, New York, on July 2, 1940. They have four children, Robert, William, Elizabeth and Margaret, age thirteen, nine, four, and two, respectively.

Professor White's honorary and professional associations include ACS, AIChE, ASEE, AAUP, AGA, MGA, AAAS, Phi Kappa Phi, Alpha Chi Sigma, Tau Beta Pi, and the Michigan Society of Professional Engineers.

ATTENTION

If anyone has the following issues of the JOURNAL OF ENGINEERING EDUCATION, please contact Marshall Lebowitz of J. S. Canner & Co., 46 Millmont St., Boston 19, Mass. *directly.*

JOURNAL OF ENGINEERING EDUCATION:

Volumes 1, nos. 1–3, 8–10; 5, nos. 7, 9; 6, nos. 2–7; 7, nos. 6–8; 8, nos. 7, 8; 9, nos. 2, 4–6, 9; 10, nos. 4, 9; 12, nos. 3–10; 13, nos. 1–6, 9; 14, nos. 2, 7.

Candid Comments

By JOHN E. DEAN

Head, Dept. of Electrical Engineering, Colorado A. & M. College

The two articles, "Evaluating Good Teaching" by R. D. Stout and "Evaluation of Engineering Teaching Ability" by T. H. Evans plus your invitation for comments in the May issue of the JOURNAL, "stir me to take pen in hand." As Stout and Evans so ably point out it is difficult for an administrator to determine the calibre of teaching of members of his staff. Both authors agree that a good teacher should "stimulate the student in independent thinking" and "get the subject across." Indirect methods of measuring are suggested, as professional activity and publication.

Now, since we are dealing with a complex problem involving human behavior, why not try a simple approach? The Bible tells us that "where thy treasure is so will your heart be also", and "as a man thinketh so is he." Let us take the hypothetical engineering teacher X and, in an unguarded moment, ask him, "What's new?" If the psychological stage has been properly set, X's reply should reveal where his treasure is and of what he thinks. My experience has elicited discussions of the Dodger's pennant chances, the bonehead substitution by the football coach in last Saturday's game, or a behind the hand narration of the latest campus gossip. However, the response we are seeking is a lively narration of success or failure in a bit of research, the latest thought on Unity in the Profession or a new way of presenting a fundamental law to students.

Now the above procedure is sneaky, unethical and strictly beneath the professional dignity of an educator. (Why don't you try it on a colleague sometime?) However, let us be serious for a moment. Have you ever, when the last paper is graded and the family long since in bed and asleep, pondered the problem of how to get across the concept of entropy or power factor to that thick headed —— in the last row? Or have you ever been struck by the idea of a classroom demonstration that is of the essence? Be honest with yourself—do you enjoy teaching, your contacts with students and their problems in the classroom and out? Do you feel that training young men and women to practice in the field of engineering is more important than practicing yourself, in spite of the financial rewards the latter can bring? By your answers you shall know whether or not you are a good teacher and that is what matters.

THE T-SQUARE PAGE

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Descriptive Geometry Helps the Surveying Instructor

By ROBERT P. VREELAND

Assistant Professor of Civil Engineering, Yale University

Because of the reduction of time devoted to surveying courses and the elimination of spherical trigonometry from most Civil Engineering curricula, the necessary background for understanding methods of azimuth determination must

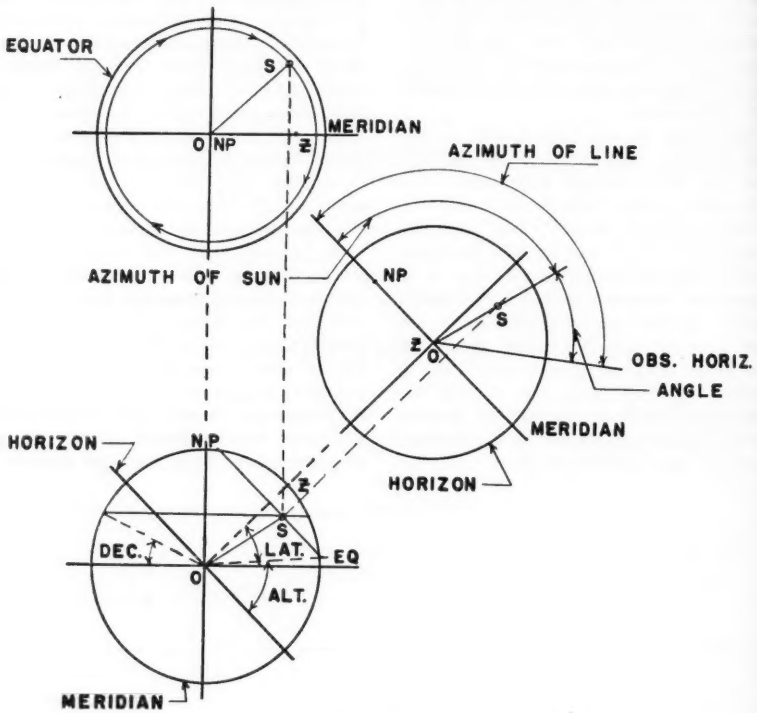

FIG. 1.

be provided in the most efficient manner possible. We have found that the approach by means of Descriptive Geometry has enabled the students to grasp readily the basic relationships between the angles in the astronomical triangle.

The problem (illustrated in Figure 1) is to determine the azimuth of a survey line (the clockwise angle the line makes with true north). The field procedure in brief is to measure the horizontal angle between the sun and the line and the vertical angle (altitude) between the horizon and the sun. Assumed known are the declination (angle between the equator and the sun) and the latitude (angle between the equator and the observer or between the horizon and the north pole). In Figure 1, then, the latitude locates in the plane of the observer's meridian, the observer's horizon and zenith with respect to the equator and pole. The declination locates the sun's path for the day with respect to the equator. Then the altitude locates the sun on its daily path. This position of the sun may then be projected onto the equator view and finally transferred to the horizon view thereby determining the azimuth of the sun. This angle is then added to (or subtracted from) the observed horizontal angle to obtain the azimuth of the line.

If Polaris (the North Star) is used instead of the sun for azimuth determination, the star's position on its daily path cannot be located sufficiently accurately by its altitude since this quantity varies only a few degrees during the course of a day. It is therefore located in the plane of the equator by its Greenwich Hour Angle (the angle between the Greenwich meridian and the star). This angle is known if the time of the observation is noted. The star is then projected from the equator view into the meridian view and finally into the horizon view as before.

It is possible of course to derive by plane trigonometry relationships between these angles. However the principal value of this method would seem to lie in its simplicity and in the use of a subject with which the engineering student is familiar.

Lisle Abbott Rose

Dr. Lisle Abbott Rose had been selected to become Editor of the JOURNAL OF ENGINEERING EDUCATION on July 1, 1955. But on the evening of May 23 Lisle had a sudden heart attack which almost immediately proved to be fatal. The death of Lisle is a great loss to the Society and to the College of Engineering of the University of Illinois. His boundless energy, enthusiasm, clear thinking, and gracious good humor will be missed.

Lisle wasn't an engineer, but through his long association with engineers and technical editing, both at the University of Illinois and Michigan College of Mining and Technology, he knew engineering education and its problems. His interest in ASEE was deep and continuous. He was a long-time member of the English Division and was serving as its vice-chairman at the time of his death. Other recent ASEE activities were chairman of the Public Relations Committee, co-author with Professor John C. Reed of the University of Florida of the new Guide for Annual Meetings, and Chairman of the Local Annual Meeting Committee at the University of Illinois in 1954. Lisle had many plans for the future and the Executive Board and General Council were looking forward to vigorous and stimulating results.

To Mrs. Rose and their two sons, the Society extends its most sincere sympathy. May the simplicity of this expression represent the depth of our feelings.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, University of Illinois, Urbana, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

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AUSTIN, WALTER JAMES, Research Associate Professor, Civil Engineering Department, University of Illinois, Urbana, Ill. Clyde E. Kesler, W. M. Lansford.

BACON, WILLIAM E., Technician Recruiting Engineering Personnel, General Electric Company, Schenectady, N. Y. V. E. Neilly, Harold Hecklin.

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BARTLESON, EDWARD E., Staff Assistant Personnel Relations, American Telephone and Telegraph Co., New York, N. Y. Donald A. Bridgman, Russel A. Deller.

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DECICCO, MICHAEL A., Assistant Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. W. W. Turner, Hugh P. Ackert.

EDINGTON, WILLIAM F., Head of Psychology Section, English and Psychology Department, General Motors Institute, Flint, Mich. C. A. Brown, Harold M. Dent.

FROSSI, PAOLO E., Electrical Engineer, Societta Edison, Milano, Italy. W. R. Woolrich, W. Leighton Collins.

GOETZ, BILLY E., Professor of Industrial Management, Massachusetts Institute of Technology, Cambridge, Mass. Arthur Lesser, Jr., Eugene Hunt.

GOLDBERG, MAXWELL H., Professor of English, South College, University of Massachusetts, Amherst, Mass. Lisle A. Rose, W. L. Everitt.

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HALL, WILLIAM J., Research Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. N. M. Newmark, W. Leighton Collins.

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HARRIS, ORVILLE RALPH, Associate Professor of Electrical Engineering, University of Virginia, Charlottesville, Va. L. R. Quarles, J. L. Vaughan.

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HECKELMAN, RICHARD W., Instructor in Electrical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitola, Russell C. Putnam.

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ORLOB, GERALD T., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. E. P. Popov, Karl S. Pister.

OXFORD, CARL J., JR., Research Engineer, National Twist Drill and Tool Company, Rochester, Mich. Orlan W. Boston, Robert E. McKee.

PEARSON, ROBERT H., Assistant Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. Ronald V. Giles, John L. Rumpf.

POUCHER, MELLOR P., Instructor in Engineering Science, University of Western Ontario, London, Ontario, Canada. L. S. Lauchland, W. S. Wilson.

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RICH, JOSEPH A., JR., Associate Professor of Management Engineering, Newark College of Engineering, Newark, N. J. Oliver J. Sizelove, W. J. Jaffe.

RICHARDS, WILLIAM L., Instructor—General Extension, College of Engineering and Architecture, Pennsylvania State University, University Park, Pa. Kenneth Hunter, V. E. Neilly.

RIEDESEL, GERHARD A., Research Engineer, Division of Industrial Research, State College of Washington, Pullman, Wash. James H. McFerron, Roger H. Nelson.

SEGNER, EDMUND PETER, JR., Instructor in Civil Engineering, Texas A. & M. College, College Station, Texas. R. L. Peurifoy, S. R. Wright.

SIESS, CHESTER P., Research Associate Professor, Civil Engineering Department, University of Illinois, Urbana, Ill. Clyde E. Kesler, W. Leighton Collins.

STALLMEYER, JAMES E., Research Assistant Professor, Civil Engineering Department, University of Illinois, Urbana, Ill. N. M. Newmark, W. Leighton Collins.

STANEK, FLOYD J., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. Omar M. Sidebottom, W. Leighton Collins.

STEELE, MONTGOMERIE C., Research Associate Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. J. O. Smith, W. Leighton Collins.

TORNQUIST, THOMAS E., Editor, Engineering Department, The Ronald Press, 15 East 26th Street, New York City, N. Y. George W. Farnham, W. Leighton Collins.

VANDREY, COLVIN, Assistant Professor of Civil Engineering, South Dakota State College, Brookings, S. Dak. Emory E. Johnson, Wm. H. Gamble.

VON KAENEL, JOHN C., Instructor in Drawing Design, Clemson A. & M. College, Clemson, South Carolina. James H. Sams, Joseph E. Shigley.

WAIBLER, PAUL J., Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash. James B. Morrison, Morris E. Childs.

WILSON, ROBERT E., Head of Chemical Engigineering Department, University of Dayton, Dayton, Ohio. Shao-Ti Hsu, Andrew R. Weber.

WOLFE, HUGH C., Professor of Physics and Head of Physics Department, The Cooper Union School of Engineering, New York 3, N. Y. Norman L. Towle, Frederic H. Miller.

YUSTER, SAMUEL T., Professor of Engineering, University of California at Los Angeles, Cal. Wesley L. Orr, C. Martin Duke.

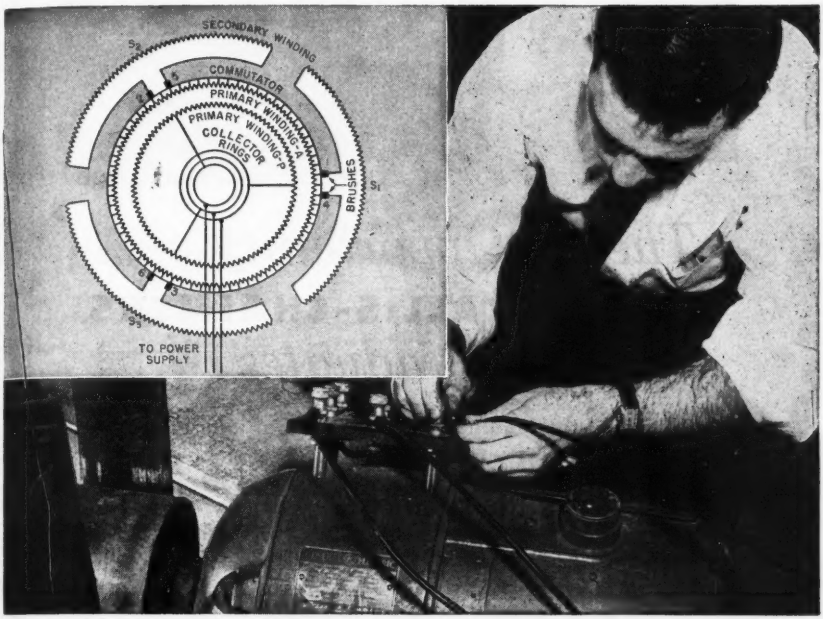
54 new members this list

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute of Technology	April, 1956	J. W. Graham, Jr., Carnegie Institute of Technology
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	R. M. Kerchner, Kansas State College
Michigan	Wayne University	May 6, 1956	G. H. Howell, Wayne University
*Middle Atlantic	New York University		C. C. Carr, Pratt Institute
Missouri-Arkansas	St. Louis University	April 7, 1956	J. B. Macelwane, St. Louis University
National Capital Area	Capital Radio Engineering Institute	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	University of Maine	Oct. 8, 1955	E. R. McKee, University of Vermont
North Midwest	South Dakota State College	Nov. 4–5, 1955	L. L. Amidon, South Dakota State College
Ohio	Ohio State University	April 28, 1956	E. C. Clark, Ohio State University
*Pacific Northwest			J. B. Morrison, University of Washington
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1955	R. G. Moses, Pasadena City College
*Rocky Mountain	Denver University		W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 14–15, 1955	B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No Date Set.



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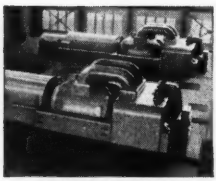

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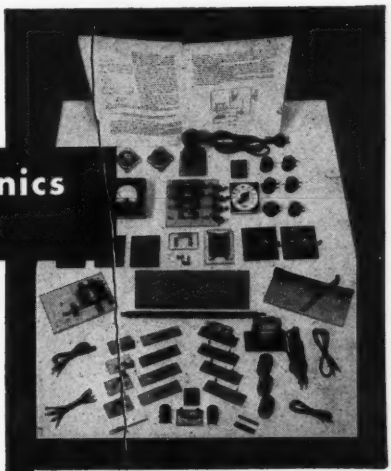

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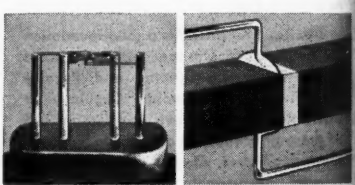

Left, new transistor, magnified 6 times. Right, sketch of area where wires are bonded.

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